POWER PLANT ENGINEERING

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Calumet Station

DETAILS OF CONSTRUCTION OF THE LATEST ADDITION TO CHICAGO'S VAST ELECTRICAL SYSTEM

DESTINED TO BECOME one of the largest power stations in the country, the initial unit of the new Calumet Station of the Commonwealth Edison Company is the embodiment of all that modern engineering methods and human ingenuity have thus far been capable of achieving. It is the last word in power plant construction. This station, the initial unit of which has recently been completed at a cost of approximately $10,000,000, is the latest addition to the already vast Commonwealth Edison Co. system. It will bear the same relation to the south side of Chicago that Northwest Station bears to the opposite side of the city. The Fisk and Quarry St. stations of the company occupy a more or less central location.

The plant is located on the west bank of the Calumet River, near Commercial Avenue and East 100th St., South Chicago, in the heart of a rapidly growing industrial district. Although located on the Illinois-Indiana State line, Calumet Station will supply power only to the former state, but will cover a large portion of the Calumet-South Chicago manufacturing district and will supply needed power for industrial development for at least 2 yr. to come. The new station is connected to the Commonwealth Edison system by two underground

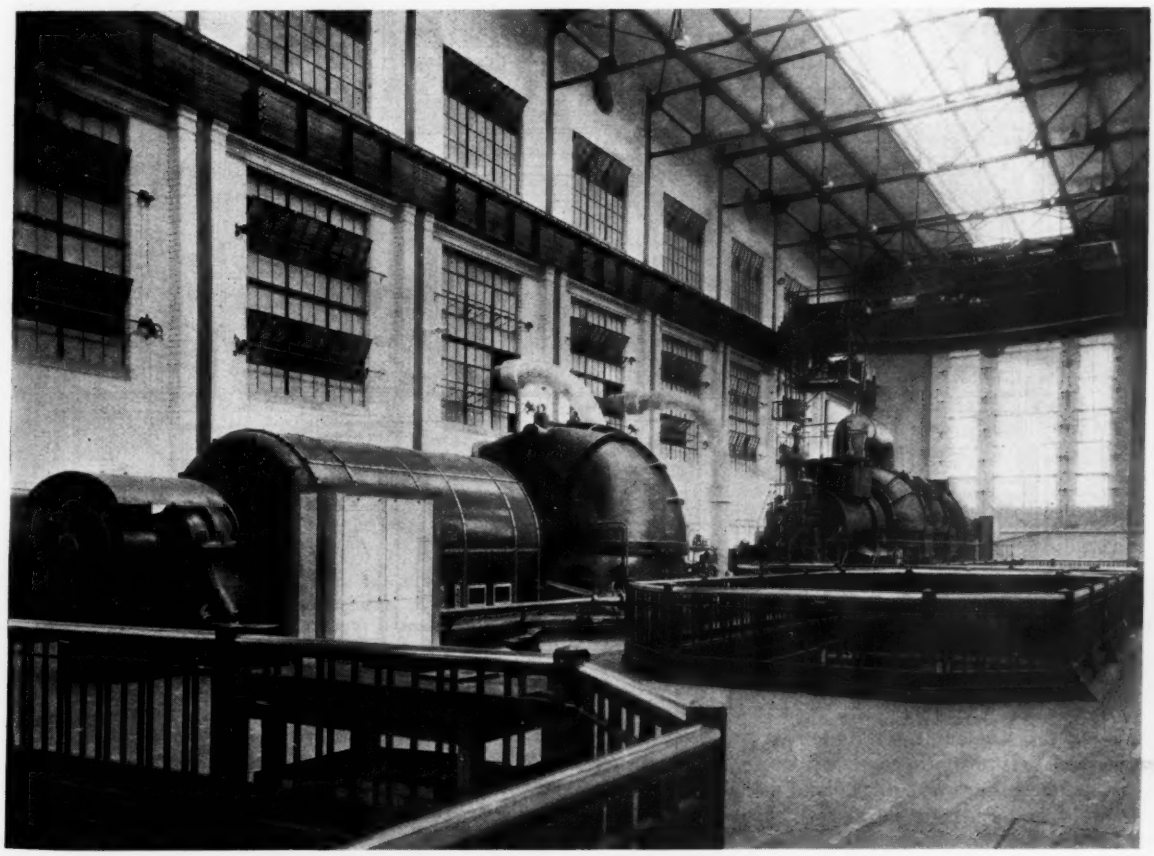


FIG. 1. GENERAL VIEW OF TURBINE ROOM

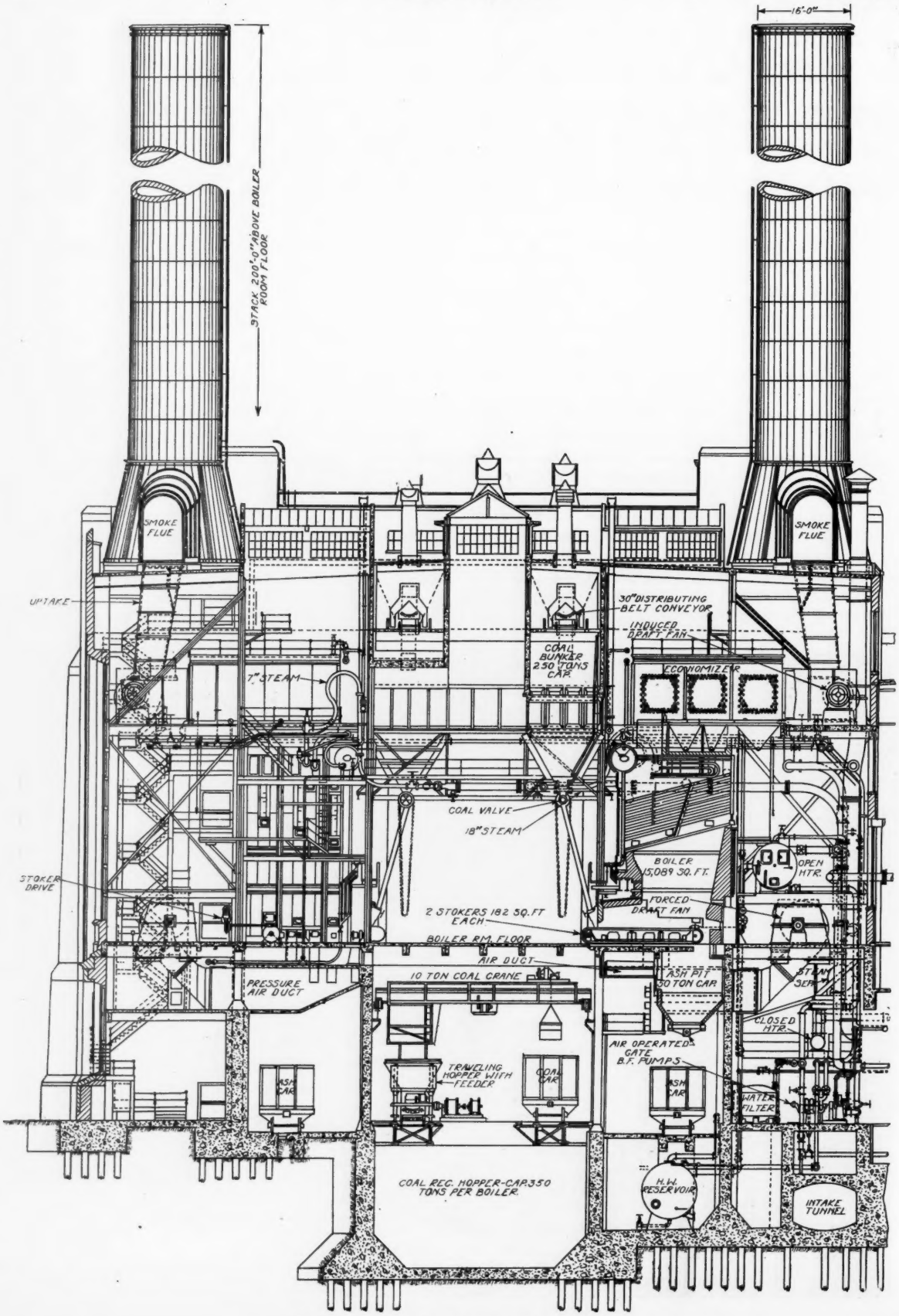


FIG. 2. SECTION THROUGH BOILER HOUSE

tie lines to Fisk Street, which it is the company's plan to operate at a potential of 33,000 v. If the plan proves successful, this voltage will be the highest voltage ever carried in an underground cable in America.

General Features

The ground area occupied by the plant comprises some 43 acres. This may seem to be an immense area; but when it is considered that present day practice makes it essential that 150,000 T. of coal be kept on hand at a station of this type, the necessity for the large ground area will be readily appreciated. Ample trackage has been provided for the efficient delivery and handling of this large quantity of coal in the shortest possible time.

For the time being, Calumet Station will be a 60,000-kw. plant. Ordinarily 60,000 kw. sounds like a large installation, but when it is associated with a system comprising some 500,000 kw., 60,000 is not of so much significance. While the ultimate capacity of the plant as planned at present, calls for six 30,000-kw. units or a total of 180,000 kw., it is impossible to predict with any degree of accuracy the ultimate capacity of the plant or the probable size of future units. If the history of development in power plant equipment during the past 20 yr. may be used as a basis for prediction, it is entirely probable that the future units will be larger.

The physical arrangement of the building is similar to that of the other Commonwealth Edison plants, comprising a boiler house which includes the coal unloading and handling equipment, a turbine room, a transformer house and the electrical distribution room or switch house. The transformer house in this case is located between the turbine room and the switch house. The offices are located directly above the switch house.

The building which is 217 ft. long, 285 ft. wide, and 100 ft. in height, not only conforms to the most approved principles of power plant construction but has been designed attractively from an architectural standpoint as well. The exterior is faced with pressed brick while the interior is finished off in white enameled brick and tile. The arrangement of equipment is such that a minimum of artificial illumination is required.

Sixty-five per cent of the total building volume is occupied by the boiler room. This large ratio of boiler room volume to total building volume, in plants of this type has become necessary, due not only to the decreasing size of the generator units per kilowatt capacity but also to the increased height of modern boiler settings and the additional space required for economizers. Coal handling apparatus is also playing a more and more important part in determining the size of the boiler house in every new development. In the first central stations, the boiler room volume was about equal to the engine room volume. At Calumet, the turbine room takes up only 15 per cent of the total building volume.

In connection with the coal handling system, an interesting departure from the usual methods employed

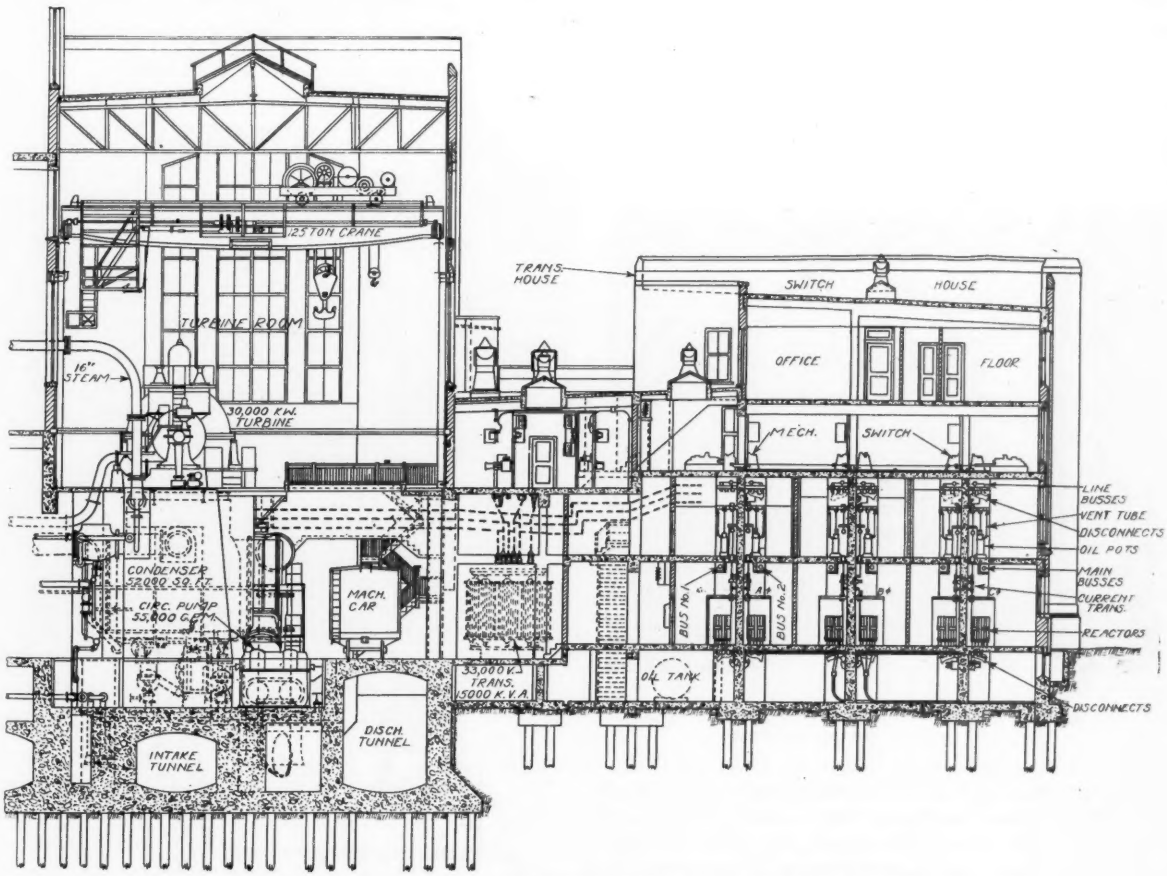


FIG. 3. SECTION THROUGH TURBINE ROOM AND SWITCH HOUSE

in power plants is seen in the installation of a Bradford breaker. Whereas roll crushers have always been provided for reducing the size of the coal, in this plant a breaker is used. The breaker is nothing more than a slightly inclined large steel cylinder, some 12 ft. in diameter, and 14 ft. long. It revolves very slowly. Coal fed into one end of the cylinder is carried up by the revolution of the cylinder and is dropped as it reaches the top. It strikes the bottom of the cylinder and is broken up and discharged through holes in the shell of the cylinder, so it is absolutely necessary for the coal to be broken up before it can pass through into the coal handling apparatus. Those of the readers who have had to do with chain grate stokers probably realize the importance of properly sizing the coal. If it is not sized properly, it is not burned properly, and is dumped off the back end of the grate with a considerable portion of its carbon remaining.

Water for condensing purposes is taken from the Calumet River through open channels leading to the station. The matter of providing suitable condensing water, however, presented a number of difficulties because of a peculiarity in the flow of the Calumet River.

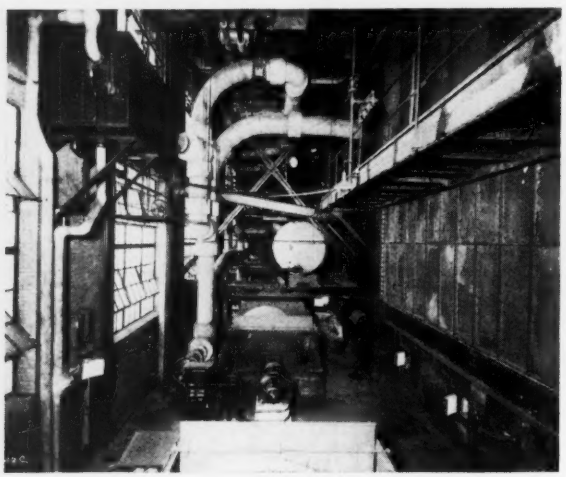


FIG. 4. VIEW BEHIND BOILERS SHOWING FORCED DRAFT FANS AND FEED WATER HEATERS

This river, due to wind conditions or changes in the lake level, reverses its direction of flow at times, and to overcome the difficulties introduced by this occasional reversal of flow, a novel arrangement in the circulating water tunnel has been provided. A long flume which extends along the river front is so arranged that the circulating water can be taken from either end and discharged at the other.

In accordance with best modern practice, the turbine room is so designed as to permit a maximum amount of daylight and air to reach the condensing equipment, the turbine floor being more in the nature of a balcony along one side of the room, underneath which is located the condensing equipment and auxiliaries. That this arrangement seems to be gaining in popularity in large plants is not to be wondered at. There is just as much need for an abundance of light in the vicinity of the condensing equipment and auxiliaries, as there is on the turbine floor, and the old time practice of installing this equipment in dark, unventilated basements has always been more or less conducive to its rapid depreciation caused by neglect.

Any arrangement which provides for an abundance of light and air on the condenser floor cannot fail to result in improved operating conditions and in better care of otherwise more or less neglected apparatus.

For handling the machinery in the turbine room, a 125-T. Whiting traveling crane, equipped with a 10-T. auxiliary hoist, is provided.

Steam is generated at a pressure of 350 lb. per sq. in. with 250 deg. superheat. Under normal conditions, the boilers are operated at 300 per cent capacity.

In the switch house, the bus arrangement is novel in that the same phases of the duplicate sets of main busses are grouped together. This arrangement precludes any possibility of short circuit between adjacent phases of one bus.

Coal Handling Equipment

Coal is delivered to the station in railroad cars which enter the boiler room basement on tracks directly

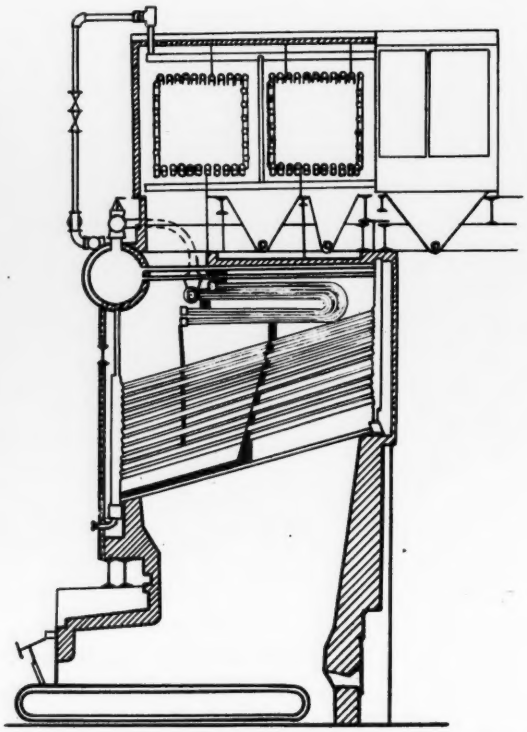


FIG. 5. TYPE OF BOILER AND TRANSVERSE TUBE ECONOMIZER USED AT CALUMET

underneath the firing aisle. A 10-T. Whiting traveling crane equipped with a clam shell bucket of two cubic yard capacity is used to remove the coal from the cars and to deliver it either to the storage bin with a capacity of 350 T. per boiler adjacent to the coal track, or to a traveling hopper. The latter is equipped with an oscillating feeder by means of which the fuel is fed to a belt conveyor, which is installed so as to deliver the coal directly to a pivoted bucket conveyor for immediate delivery to the overhead bunkers in the boiler room or to a Bradford breaker, depending upon whether the coal

is of a size suitable for use on the stokers or whether it is of such size as to require breaking before being used on the grates.

This Bradford breaker, as stated previously, consists of a large horizontal steel drum or cylinder, about 12 ft. in diameter and 14 ft. long, the interior of which is fitted with ribs or shelves. It is installed in a slightly inclined position so that as the cylinder revolves slowly, coal fed into one end will gradually work its way down to the other end. As the cylinder revolves, the coal is carried upward on the side ribs and as it reaches the top, falls to the bottom, thus breaking up the large pieces in a very effective manner. The broken coal is then discharged through holes in the side of the drum. These holes being of a small size, it is obvious that the coal passing through them will be of the correct size for use on the grates. Any foreign material such as rocks, pieces of iron, tools, etc., will, of course, not be broken up and will be carried to the opposite end of the drum where it is discharged along with any unbroken coal which may have passed through.

The properly sized coal discharged from the breaker falls onto a short belt conveyor and is delivered into the main pivoted bucket conveyor by which it is elevated to the upper part of the boiler room.

The unbroken coal from the breaker is carried by means of two 24 in. belt conveyors installed at right angles to each other as shown in Fig. 8, to a 20 by 30-in. Robins double roll crusher. The latter is driven by a 20-hp., 440-v. three-phase General Electric induction motor operating normally at 555 r.p.m. The fuel passing through this crusher is finally delivered to the same pivoted bucket conveyor referred to above. The crusher together with its associated conveyors, it will be noted, is nothing more nor less than a bypass around the breaker. An attendant in charge of this apparatus is able to remove such foreign material as may come through before it reaches the crusher. The coal handling equipment just described is installed in a room below the basement and all apparatus is driven by General Electric induction motors equipped with G. E. control. The two belt conveyors delivering coal to the crusher, are driven through W. A. Jones speed reducers, having speed ratios of 42 to 1 and 20.53 to 1 for the small and large belts respectively.

The main pivoted bucket conveyor which carries the fuel to the top of the boiler house, travels a rectangular path around the boiler house. It is a 34 by 36-in. Mead-Morrison conveyor and is driven at the upper run by a General Electric induction motor, equipped with control of the same manufacture.

Two fixed trippers installed at the upper run of the bucket conveyor, serve to deliver the coal to either of two 30-in. distributing belt conveyors, installed at right angles to the bucket conveyor above the coal bunkers.

At the receiving end, these belt conveyors are equipped with steel feeding hoppers fitted with hand operated sliding coal valves, by means of which the feed to the belts can be regulated. Automatic traveling trippers distribute the coal from the belts into the overhead coal bunkers below. All belt conveyors were made by the Robins Conveying Belt Co. while the elevating conveyor was furnished by the Mead-Morrison Company.

As installed at present, considerable dependence is placed upon the bucket elevating conveyor, since it furnishes the only means of delivering coal to the upper portion of the boiler house. This, of course, is an undesirable feature, since a serious breakdown on the part of this apparatus might cause difficulty in supplying coal to the boilers. Provision has been made, therefore, to install a duplicate conveyor in the near future, which will eliminate the entire dependence upon one piece of apparatus.

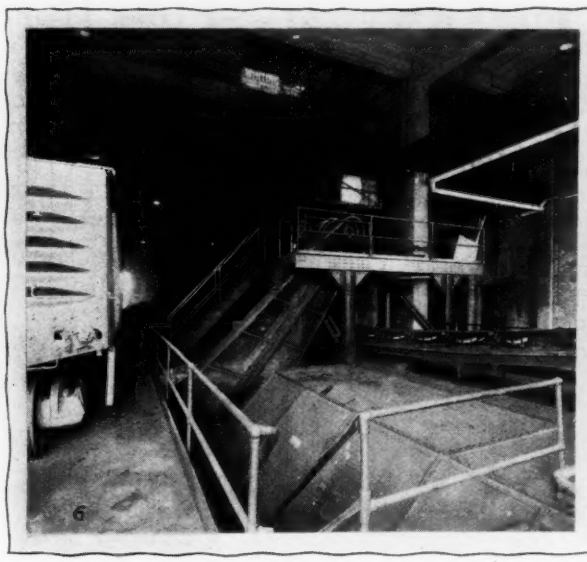


FIG. 6. PHOTOGRAPH SHOWING BRADFORD BREAKER FOR BREAKING COAL

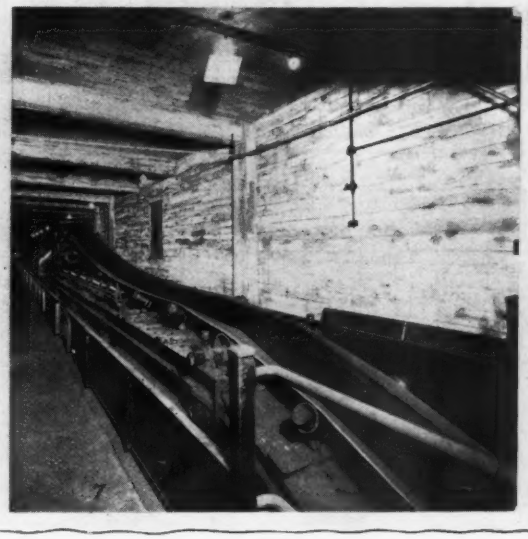


FIG. 7. ONE OF THE DISTRIBUTING BELT CONVEYORS ABOVE BOILER ROOM

Steam Generation

Steam is generated at 350 lb. pressure in seven 1500-hp. cross drum, Babcock and Wilcox boilers of the Alert type, with 24-ft. tubes 4 in. in diameter. Each boiler

has a total heating surface of 15,089 sq. ft. and are built to evaporate 150,000 lb. of water per hr. which is something over 300 per cent normal rating. The attainment of this rating is, of course, greatly a matter of stoker equipment and furnace design. The stokers, with the exception of that on Boiler No. 3 on Unit No. 2, which is of B. & W. make, will all be forced draft, chain grate stokers of the Coxe type. This stoker, while designed for small anthracite and coke breeze is well adapted for free burning, high ash coals.

There are two stokers to each boiler, each grate being 11 ft. wide and having a total grate area of 182 sq. ft. provided with its own driving motor and forced draft fan. The stoker drive motors which are 220-v. direct current General Electric Co. machines, are located behind the boilers, and drive the stokers through a worm gear which is attached directly to the rear stoker shaft. A split coupling, the two halves of which are held together by a 5/16-in. pin is interposed in the driving shaft, so that in case of a jam, the pin will be sheared off, thus protecting the driving motor.

Each boiler is supplied with forced draft by two Sturtevant Turbovane fans, installed directly behind the boilers on the boiler room floor. Each fan has a capac-

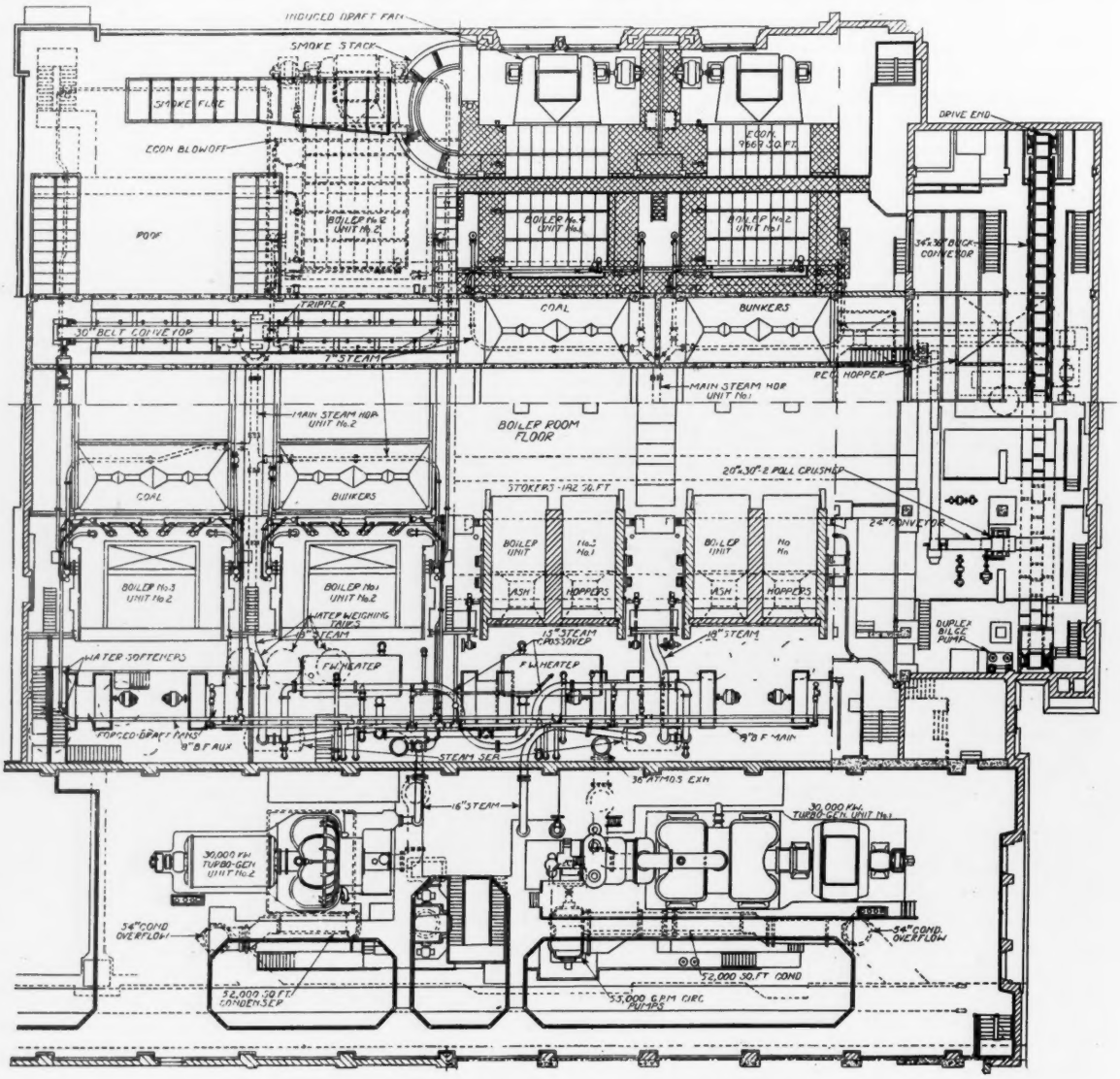


FIG. 8. PLAN OF BOILER ROOM AND TURBINE ROOM

The stoker construction is such that the air space under the grates are divided into separate and distinct zones or wind boxes. This construction not only permits direct control of the amount of air to the furnace but also its distribution through various portions of the grate surface. The speed of the stokers is variable and may change speeds as low as 7 ft. an hour to 30 ft. per hr. and upward. Each stoker is controlled separately, being

ity of 40,000 cu. ft. of air per min. against 4-in. pressure when running at 695 r.p.m. They are driven by 50-hp., 440-v., three-phase, 60-cycle, Type C. W. Westinghouse induction motors, direct connected to the fan shaft. These motors are remote controlled, through Westinghouse resistors, from the boiler fronts. The resistor units together with motor driven controllers, are installed adjacent to the fans.

All control of stoker, forced draft and induced draft fan motors is from the boiler fronts on the boiler room floor level. Push button control is provided for the fan motors, while the stoker drive motors are controlled by means of General Electric Co. direct current drum controllers. All controllers, push buttons, together with a complete set of Ellison multi-tube draft gages are mounted on a panel conveniently located at the side of each stoker. An indicating steam pressure gage, a Republic steam flow meter is installed on each boiler. Four of the seven boilers are equipped with Bailey meters, which record both steam flow and the air to the furnace. This equipment, it will be noted, enables the fireman to maintain complete control over the boiler and associated equipment at all times without leaving his post at the front of the boiler.

The induced draft fans referred to above are located at the rear of the economizers on the economizer floor, one to each boiler. These are also Sturtevant fans and are driven by 200-hp. variable speed, 2200-v., three-phase, 60-cycle Westinghouse induction motors, rated at 53.7 amp. per terminal. At full load, these motors have a speed of 490 r.p.m. They are designed to operate at 100 per cent load continuously with a 40 deg. C. temperature rise, and at 125 per cent load for 2 hr. with a 55 deg. C. temperature rise. The speed is regulated by the rotor resistance method of control, the rotor circuit being rated at 290

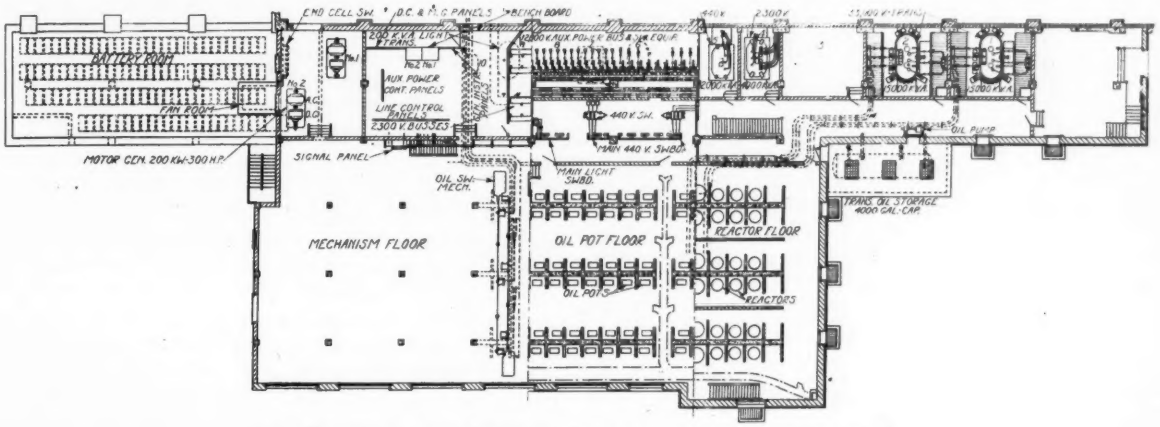


FIG. 9. PLAN OF SWITCH HOUSE AND STORAGE BATTERY ROOM

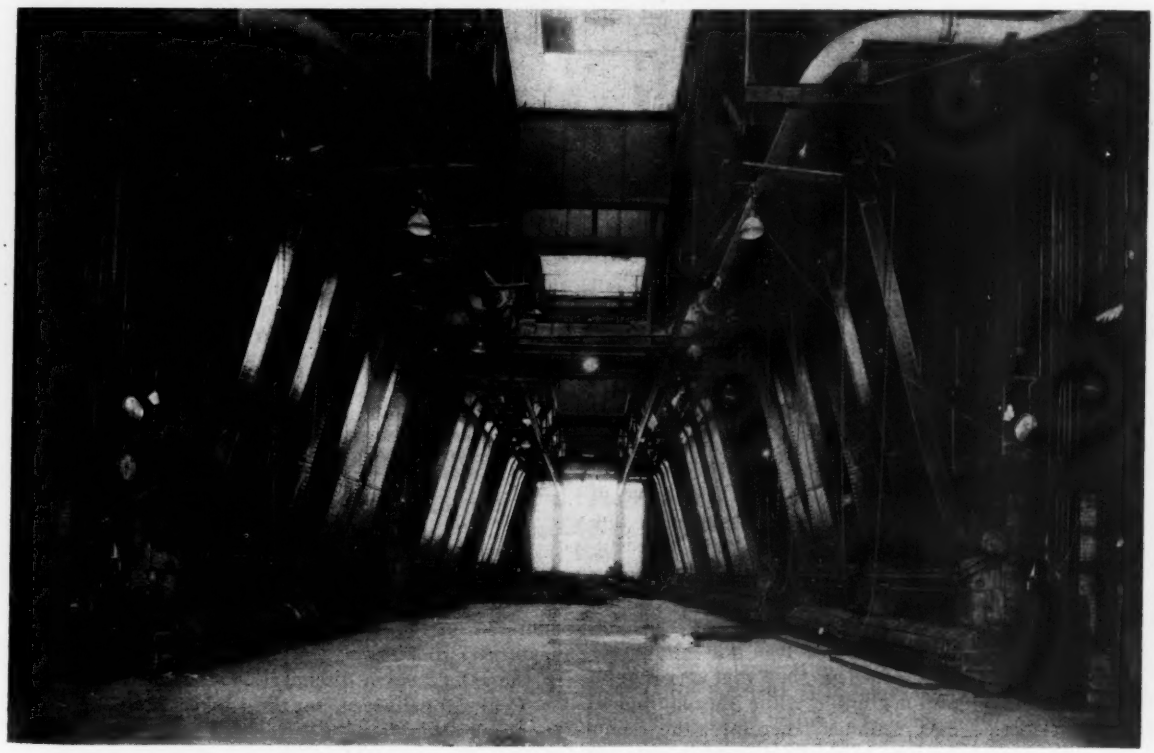


FIG. 10. GENERAL VIEW IN BOILER ROOM

amp. per ring with 310 v. between rings. As stated previously, these motors are controlled from the boiler room floor through Westinghouse resistors installed adjacent to the motors.

Economizers

The type of economizers installed at Calumet is known as the Babcock and Wilcox steel tranverse tube economizer. Steel tubes are necessary on account of the high pressure carried. Each economizer contains 432 2-in. steel tubes, arranged in three banks of 144 tubes, each giving a total heating surface of 9669 sq. ft. for each economizer. There is one economizer for each boiler, as may be noted in the accompanying illustrations, each of which is fitted with 12 units of Diamond soot blowers, for cleaning the tubes. It has been found that the external cleaning of economizer tubes can be satisfactorily accomplished by means of the soot blowers,

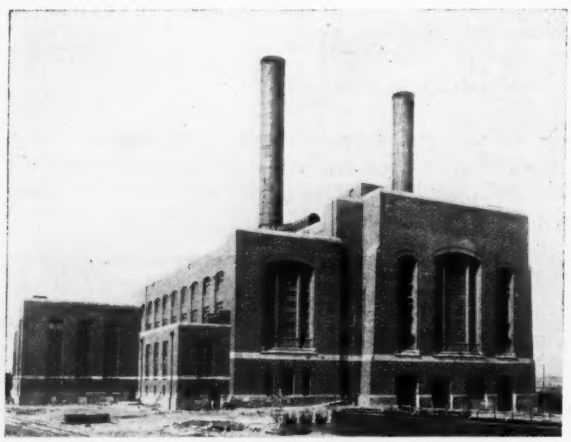


FIG. 11. CALUMET STATION

Superheated steam for blowing gives better results than saturated steam, and in plants equipped with steel economizers, superheated steam is generally used.

In connection with the use of steel economizers, it is sometimes contended that steel economizers are more susceptible to corrosion, than those of cast iron. While there is, without doubt, considerable truth in this contention, methods have been devised for checking or at least retarding the corrosion, until it is no longer of prime importance. So far as external corrosion is concerned, this is dependent primarily upon the constituents of the flue gas and where the coal contains an appreciable percentage of sulphur, corrosion will be excessive at low temperatures. It has been found, however, that by raising the temperature of the feed water entering the economizer to about 140 deg. that this corrosion is retarded and is almost negligible while the equipment remains in service. At Calumet, therefore, the economizers will receive water from the feed water heaters at a temperature of 175 deg. F. This temperature for incoming water is, of course, considerably higher than theoretical economic considerations dictate; but to overcome corrosion difficulties referred to above due to the formation of sulphurous acid on the tubes at low temperatures, the high water temperature is a physical rather than a financial necessity.

The type of boiler, together with the transverse type of economizer installed at Calumet plant, is shown in Fig. 5. The boiler, it will be noted, is a three pass vertically baffled boiler with the superheater installed above the tubes between the first and second passes. Superheaters are all of the Foster type with a total heating surface of 4052 sq. ft. Diamond soot blowers are installed on all boilers.

The transverse economizer, as will probably be evident, derives its name from the fact that the sections are so placed as to make the tubes transverse from the boiler tubes, thus giving a single gas pass over the economizer surface. It has excellent counterflow characteristics and the draft resistance is comparatively low.

The station is designed so as to provide four of the above described boilers for each generating unit, and four on each stack. Boiler No. 4 on Unit No. 2, however, is not yet installed.

The boilers themselves are set about 16 ft. above the grate in order to secure a large furnace volume for the efficient combustion of the coal. The combustion chamber volume is about 6700 cu. ft. All boiler settings are insulated with Sil-O-Cel insulation. The ash pits below the grate have a capacity of 50 tons and are equipped with air operated gates, for controlling the delivery of ashes into the railroad cars in the basement.

The water level in the boilers is automatically varied according to the load demands, by S-C feed water regulators installed on each boiler. This device keeps the water level constant on steady loads, lowers the level on excessive loads and raises it on light loads.

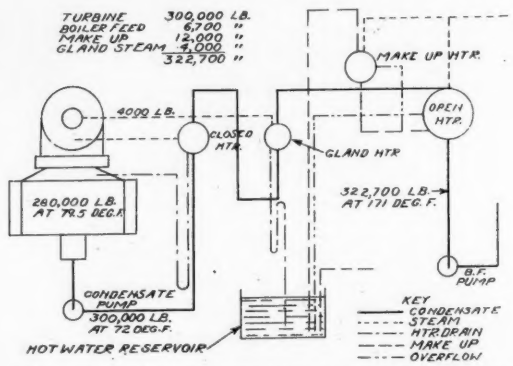


FIG. 12. DIAGRAMMATIC REPRESENTATION OF FEED WATER HEATING SYSTEM

Each boiler is fitted with Edward stop and check valves, and with 10 safety valves. The latter are arranged in five sets of two each, four sets being mounted on the steam drum and one set on the superheater. Two vertical vents to the atmosphere take care of the safety valve discharges from each boiler.

Coal is delivered to the stoker hoppers, through spouts, leading from the overhead coal bunkers and the delivery is controlled by chain operated coal valves.

Feed Water

Boiler feed water at Calumet is heated in a combination of open and closed heaters, utilizing available heat from a number of different sources. A diagrammatic representation of the system employed is shown in Fig. 12. Condensate from the main condenser is first heated

in a closed heater by steam bled from the main turbine below atmospheric pressure; then in another closed heater by exhaust steam from the high pressure packing glands on the turbine, and finally in a large open heater by exhaust from the auxiliaries. In this manner the temperature of the boiler feed is gradually raised to approximately 170 deg. F. before it enters the economizers. The condensate from the first closed heater, it will be noted, goes into the main condenser; the condensate from the second closed heater is delivered, together with the heater drain and make up water, into a hot water reservoir.

Four boiler feed pumps are provided. These are all Worthington, four-stage centrifugal pumps rated at 9000 gal. per min. each. Three of them are driven by Westinghouse steam turbines at 2250 r.p.m. while the remaining one is driven by a 400-hp., 2300-v. induction motor.

The feed water heating system described above is installed in duplicate, that is, a separate system for each of the two generating units.

order to remove any water that may come over with the steam before it reaches the turbines, large steam separators are provided. Sixteen-inch lines from the separators deliver steam to the turbines at a pressure in the neighborhood of 350 lb. per sq. in. While the ability of these steam separators to take care of great slugs of water is to be questioned, they nevertheless provide a certain amount of protection. With steam traveling along at the rate of 10,000 ft. per min. the water that may be present travels almost as fast, and it would take an unreasonably large separator to remove any considerable amount of water. The steam is traveling entirely too fast. The separators are effective, however, when small quantities of water are met with and their installation certainly will do no harm.

When the boilers are arranged in batteries of four to serve one turbine unit, a 15-in. crossover line is provided between the separators referred to so that if necessary or desirable any boiler may be used to feed any one of the generating units. This crossover may be seen on the illustrations and it will be noted, is provided with an

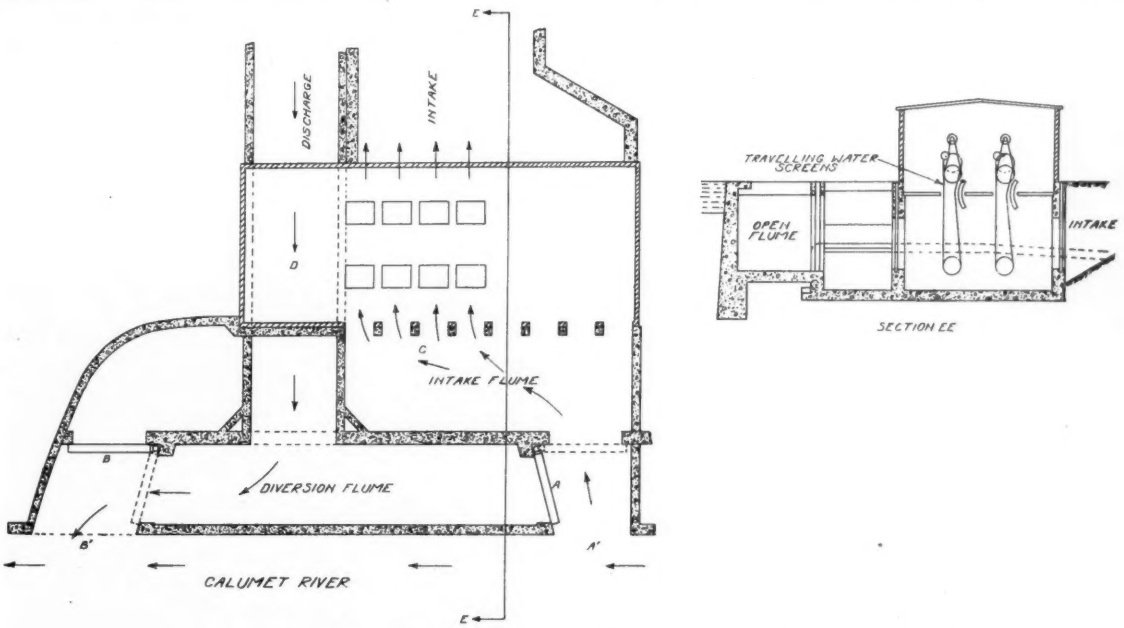


FIG. 13. DIAGRAM SHOWING METHOD OF REVERSING FLOW AT THE CRIB HOUSE

The two open feed water heaters are located on a platform in the boiler room directly behind the boilers as shown in Fig. 4. They are served with exhaust steam from the common auxiliary steam line, which is also connected to an atmospheric exhaust vent through a relief valve.

Raw water for make up is treated by the Permutit water softening system, the apparatus for which is also located on the auxiliary floor.

Steam Piping

A simplified diagram of the main high pressure steam piping is shown in Fig. 14, reference to which will make clear the manner in which the boilers are grouped to feed the generator units. Each four boilers, it will be seen, serves one generator unit.

Steam is taken from the boilers through 7-in. headers connected into main 18-in. headers as shown. In expansion bend. The auxiliary steam lines are fed from this crossover line near the point where the ends connect into the separators. Edward valves are used on practically all of the steam and water piping.

The type of joints used in the steam lines is shown in Fig. 17. This is a modification of the "Vanstone" type of joint, and is made with the flange fairly loose on the pipe but with the pipe faced over the flange where the joint is to be made. The faces making the joint are carefully machined and the edges are scraped and welded at the tip after the pipe is made up. No gaskets are used. The object of the welding is merely to overcome trouble due to leaks caused by unevenness in the faces of the pipe ends. The bolts passing through the flanges relieve the weld of any strain. This type of joint has been in use for years at the other stations of the Commonwealth Edison Company without slowing even the slightest signs of leaking.

Auxiliaries

Most of the station auxiliaries are located in the basement of the boiler room. The dividing wall between the boiler and turbine rooms is cut away at this point so that the auxiliaries are virtually on the condenser floor of the turbine room. Besides the four boiler feed pumps and the Permutit water softening apparatus, already mentioned, there is installed here the following equipment:

Two Worthington centrifugal service pumps; one is driven at 2100 r.p.m. by a Westinghouse turbine, and the other, at 1760 r.p.m. by a 7.5-hp., 440-v. General Electric induction motor.

One Sullivan Machinery Co. single-stage air compressor driven by a 2300-v. Westinghouse motor.

One Worthington four-stage, centrifugal boiler washout pump driven by a 2300-v. electric motor.

Three filter tanks, of Jewell Filtration Co. manufacture, each fitted with a 100,000-gal. per day controller made by the Simplex Valve and Meter Co.

Three large water weighing tanks.

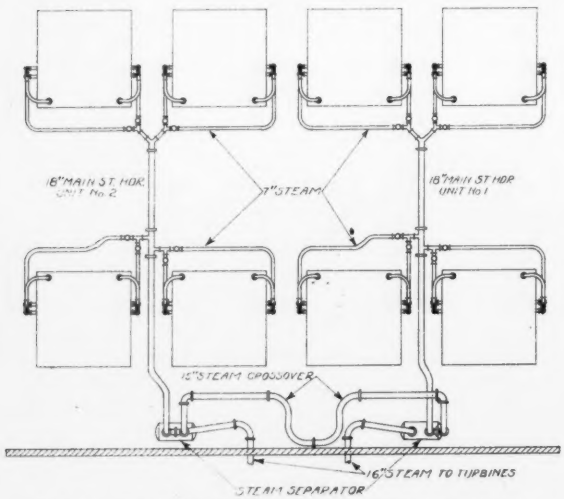


FIG. 14. DIAGRAM SHOWING MAIN STEAM HEADERS

One turbine, oil filter with DeLaval motor driven centrifugal separator, and two motor driven oil pumps for pumping oil from the filter to the turbine. These pumps are centrifugal units rated at 50 gal. per min. against a 50-ft. head, made by the American Steam Pump Co. and are driven at 1700 r.p.m. by 3-hp., 440-v. General Electric motors.

Two Yeomans vertical bilge pumps, driven by 15-hp., 440-v., 3-phase General Electric motors.

In addition to the foregoing list of apparatus, there is also installed all the condensing equipment and air washing apparatus, to be described later.

Generating Units

There are installed at present, two 30,000-kw. turbogenerating units, described as follows:

Unit No. 1 is a Westinghouse tandem compound machine, rated at 35,300 kv.a., 12,000 v., 1700 amp., 3-phase, 60 cycles, 1200 r.p.m. with direct connected exciter. It is served by a Westinghouse condenser of approximately 52,000 sq. ft. of cooling surface and supplied by a pump with a capacity of 55,000 gal. per min. An interesting feature of the unit is that the expansion joint between the turbine and condenser is made of rubber.

Unit No. 2 is a General Electric, 17-stage, single impulse unit, rated 30,000 kw., 80 per cent power factor, 12,000 v., 3-phase, 60 cycles, 1800 r.p.m., also with direct connected exciter. Its best point of economy is at about three quarters load. Steam is admitted all the way around the rotor of the first wheel and it is fitted with primary and secondary admission valves.

This unit exhausts into a 52,000 sq. ft. Worthington surface condenser served by Worthington hydraulic vacuum pumps, and a 55,000-gal. per min. circulating pump.

The field rheostats for each unit and its associated exciter are mounted on a panel against the wall at the side of the generators. Both are motor operated rheostats, remote controlled from the main operating room. The resistance grids are installed in a separate room adjacent to the panels.

The circulating pumps for both units are driven by 2200-v. induction motors, rated at 800 hp. apiece.

The condenser on Unit No. 1 is served by two Westinghouse Le Blanc air pumps, equipped with Elliott Co. twin strainers. One is turbine driven through a reduction gear, and the other direct connected to a Westinghouse induction motor rated at 150 hp. operating at 700 r.p.m. The condensate pumps for this unit are also of Westinghouse manufacture, rated at 1000 gal. per min. at 1750 r.p.m. and as in the case of the air pumps, one is motor driven and one turbine driven. Crane valves and fittings are used throughout on the condenser equipment piping.

The Worthington condenser is served by two centrifugal condensate pumps and by four size 8 Worthington vacuum pumps. In this case, also, the two condensate pumps are driven by a turbine and by a 2300-v. General Electric motor, respectively.

For washing and cooling the air to the generators there are installed two complete Carrier air washers. The generator ventilating system is a closed system in which the air used for cooling is used over and over. All the heat absorbed from the winding is removed by the washer before it is recirculated.

Condensing Water

Water for condensing purposes is obtained from the Calumet River upon the bank of which the station is built. A double set of Link Belt revolving screens passing over pulleys above and below the water, are installed in the crib house at the intake flume. The object of using two sets of traveling screens instead of one set of traveling screens and two sets of stationary screens as is used in the other stations of the company, was to cut down the hand labor required for the cleaning of stationary screens.

The arrangement of flumes at the crib house is as depicted in Fig. 13 the diversion flume being provided to eliminate trouble which might be caused by the reversal of the flow of water in the river. It is obvious that without an arrangement of this kind, a reversal in the direction of flow would cause the warm water from the discharge flume to be drawn into the intake flume, a condition which would result in a decrease in vacuum.

The arrangement here shown operates as follows: Suppose the direction of flow in the river is from right to left. For proper operation under this condition, the diversion gates A and B will then be the positions shown, and the path of the water will be as indicated by the arrows. If now, the river should reverse, it is evident that unless the position of diversion gates were changed, the water discharging at B′ would be immediately drawn into A′ again. This would cause trouble. If, however, the diversion gate B is turned to go through 90 deg. so as to close up the diversion flume at the left, and if at the same time, diversion gate A is also swung through 90 deg. opening up the diversion flume at the right and closing the intake passage, the water will enter at B′ and be discharged at A′, thus transposing the relative positions of the intake and discharge passage. The discharge flume, it will be seen, is so constructed as to pass above the intake flume.

All traveling water screens in the crib house, and also the diversion flume gates, are operated by electric motors.

Electrical Features

In the design and layout of the electrical equipment at Calumet, safety, reliability, and simplicity have been the prime consideration.

Current is generated at a pressure of 12,000 v. by the two 30,000-kw. turbo-alternators previously described, and although the station is tied in with Fisk Street Station practically all distribution takes place at generated voltage. Twelve thousand-volt leads from the generators pass through a specially constructed duct directly to the main busses in the switch house.

The switch house, as will be noted from the drawings, is a four-story structure with a basement, the top floor of which is used for office purposes. The 12,000-v. feeder switches are installed on the second floor while the mechanism for operating these switches is located on the floor above. On the first floor are installed the line reactors and in the basement the feeders leave the building through underground ducts.

The arrangement of the busses is extremely novel, and is quite different from anything heretofore used in generating stations. There are two sets of busses. Instead of grouping the three phases of each bus together as usual, however, the duplicate phases of the main busses are grouped together, the phases themselves being separated widely; that is, instead of grouping the A, B, and C phases of one bus on one side of the room and the A, B, and C phases of the other bus on the other side, the A phases of the two busses are grouped on one side of the room, the two B phases in the middle and the two C phases on the other side. With this arrange-

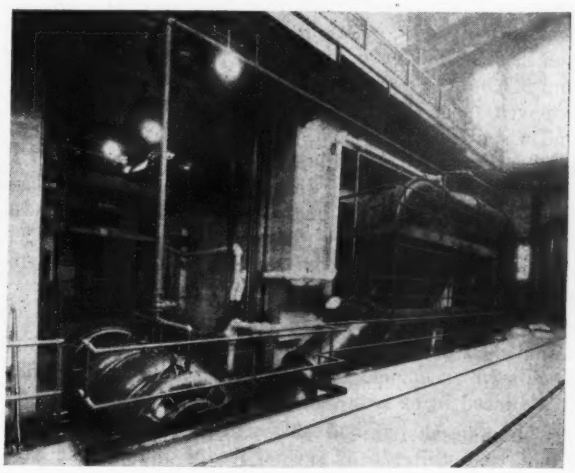


FIG. 16. VIEW SHOWING ONE OF THE CONDENSER UNITS

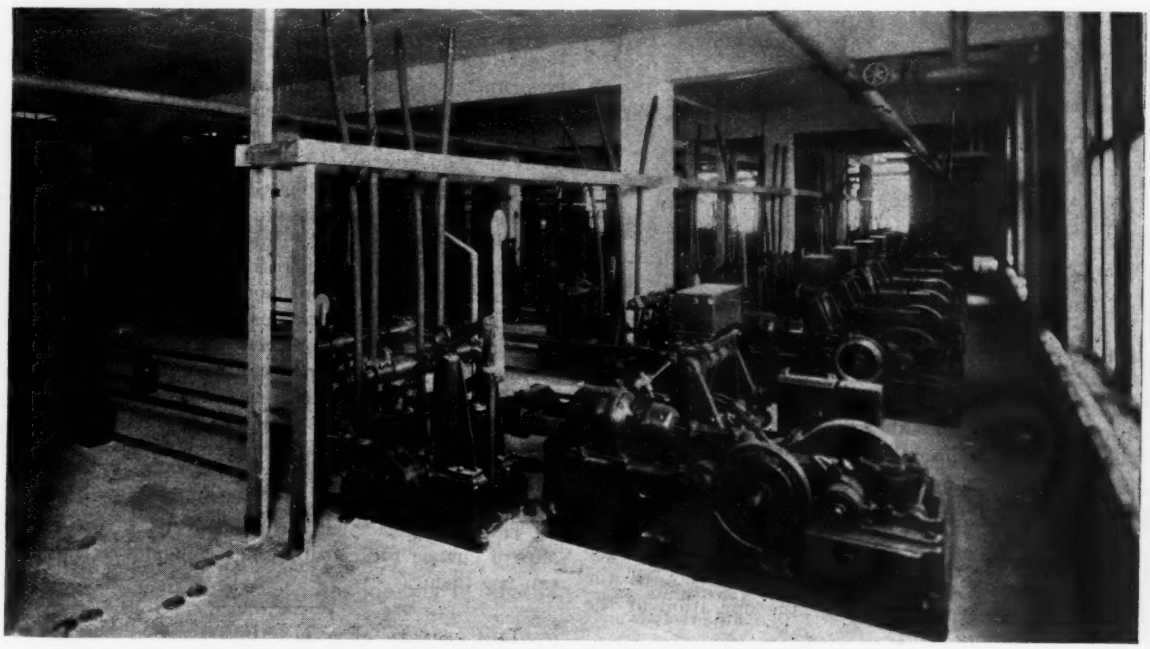


FIG. 15. VIEW OF OIL SWITCH OPERATING MECHANISM

ment, the phases are so far separated that the possibility of crosses between phases is very much eliminated.

Another feature of great interest is the type of feeder switches and operating mechanism installed. This type of switch, known as the General Electric, Type F, Form AD-17 oil circuit breaker, is an entirely new development and embodies several novel features. The oil tanks are oil-tight, gas-tight, and electrically dead. Each pole is installed in an individual concrete compartment and is mounted permanently on a truck so that it can be removed from the cell quickly for inspection or repair, and a spare unit inserted. The contacts and other current carrying parts can be removed from or replaced in the oil tanks as a unit. In each oil tank there is a gas vent through which the gases generated in the tank due to opening the circuit are discharged. By merely unloosening two bolts, the wooden operating rod can be disconnected, and the switch removed from the cell.

The electrical contact to the circuit is automatically established or broken by means of two sets of copper fingers which engage contact blades on the switch, when it is placed in or removed from the cell.

These breakers are installed in conjunction with disconnecting switches of special design and of the same capacities as the switches themselves. These disconnecting switches are operated by the same mechanism as the breakers.

The circuit breakers and disconnects are motor operated through three paralleling mechanisms, one per pole, which are actuated by a heavy main operating mechanism, shown in Fig. 15, so constructed that the motor

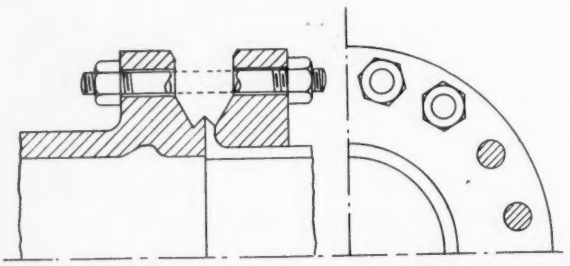


FIG. 17. TYPE OF JOINT USED IN HIGH PRESSURE PIPING

which operates it compresses a number of strong spiral springs. The springs when compressed have sufficient energy for both opening and closing strokes. As a safety feature the motor follows the spring action in the opening stroke to assure an absolute opening operation. The disconnecting switches are so connected to this mechanism that they close before the breaker closes. On the opening stroke, the opening of the breakers is followed shortly after by the opening of the disconnecting switches; the circuit then being opened cannot be closed until the springs are again compressed for the operation of the opening and closing stroke.

The operating mechanisms themselves are controlled by three-button control switches with visual indicating signals, located in the main control room.

The two 15,000-kw., 33,000-v. transformers which will step up the voltage for the Fisk Street tie lines are located on the ground floor, and installed on trucks so that they can be removed from the compartments in which they are placed with a minimum amount of work.

The station service current is supplied from transformers in the switch house at two voltage, namely 440 v. and 2300 v. All power for operating switches and for direct current motors is supplied at 230 v. direct current from motor generator sets or storage batteries.

The power for all auxiliary motors above 50 hp. is supplied at 2300 v., 60 cycles alternating current, while the smaller motors are supplied from the 440-v. circuit. Operating the large auxiliary motors at 2300 v. is a new departure with the Commonwealth Edison Co. although there are several stations in the east where this method has proved successful. The power transformers for station service receive current from the main busses through reactors. The two main busses are tied together through two reactors, and the middle point between these reactors is the point from which the station transformrers are supplied.

It will be noted that with the exception of the boiler feed pumps and one of the auxiliaries on each turbine, all auxiliaries are motor driven.

CONCLUSION

CALUMET STATION was first "cut in" on the system of the Commonwealth Edison Co. on December 27, 1921, although at that time construction work had not been completed. While the first unit of the new station is now barely completed, plans are already under way for the construction of the second unit. All engineering was done by Sargent and Lundy, Inc., of Chicago.

In concluding this description, credit is hereby extended to L. A. Ferguson and W. L. Abbott, of the Commonwealth Edison Co., for privileges which made possible the preparation of this article.

WHILE MUCH of the surplus property held by the government at the close of the war has been disposed of by sale and by transfer to departments needing it, there remains a large stock to be sold, which is being added to by new declarations of surplus from time to time.

It is the plan of Major Glen E. Edgerton, director of sales, to dispose of the entire War Department surplus within a year so as to relieve the market of its effect as soon as possible, rather than draw out the process longer. The stock now on hand represents a cost to the government of some $190,000,000 on which the recovery is averaging about 25 per cent as the most salable of the materials have already been moved. Types of material now offered include electrical equipment, hand tools, lumber, chemicals, oils, metals, paints, engineering equipment, machine tools, aeroplanes and parts, wagons, building material, buildings, leather, greases, office equipment and packing cases.

These materials will be extensively advertised, and offer a chance for considerable economies to those who can use them.

THE OBJECTS of a new investigation being undertaken by the Bureau of Mines at the Pittsburgh experiment station on the determination of composition of gases arising from a thin fuel bed are: by blowing air at known rates through a fuel bed of known thickness, formed from anthracite, coke or bituminous coal, to find out the quantity and composition of the gases above the fuel bed; and so show how much air must be admitted to burn their combustible constituents.

Shavings and Refuse as a Boiler Fuel

FURNACE REDESIGNED FOR WOOD-BURNING. BY EINAR WINHOLT

MANY industrial establishments produce light, heat and power in their steam power plants. Besides this, the plant has another function in many cases, namely, to dispose of wood shavings and refuse from the manufacturing process. The primary reason for burning the refuse under the steam boilers was to get rid of it in the easiest and least expensive way and as out whereby the refuse was burned with more efficiency than formerly was the case. In so doing, each plant followed out its own ideas and some adapted ideas which had proven successful in other plants.

In burning wood shaving, the common procedure was to place the dust collector or cyclone on top of the roof above the boiler room and lead the shavings through a

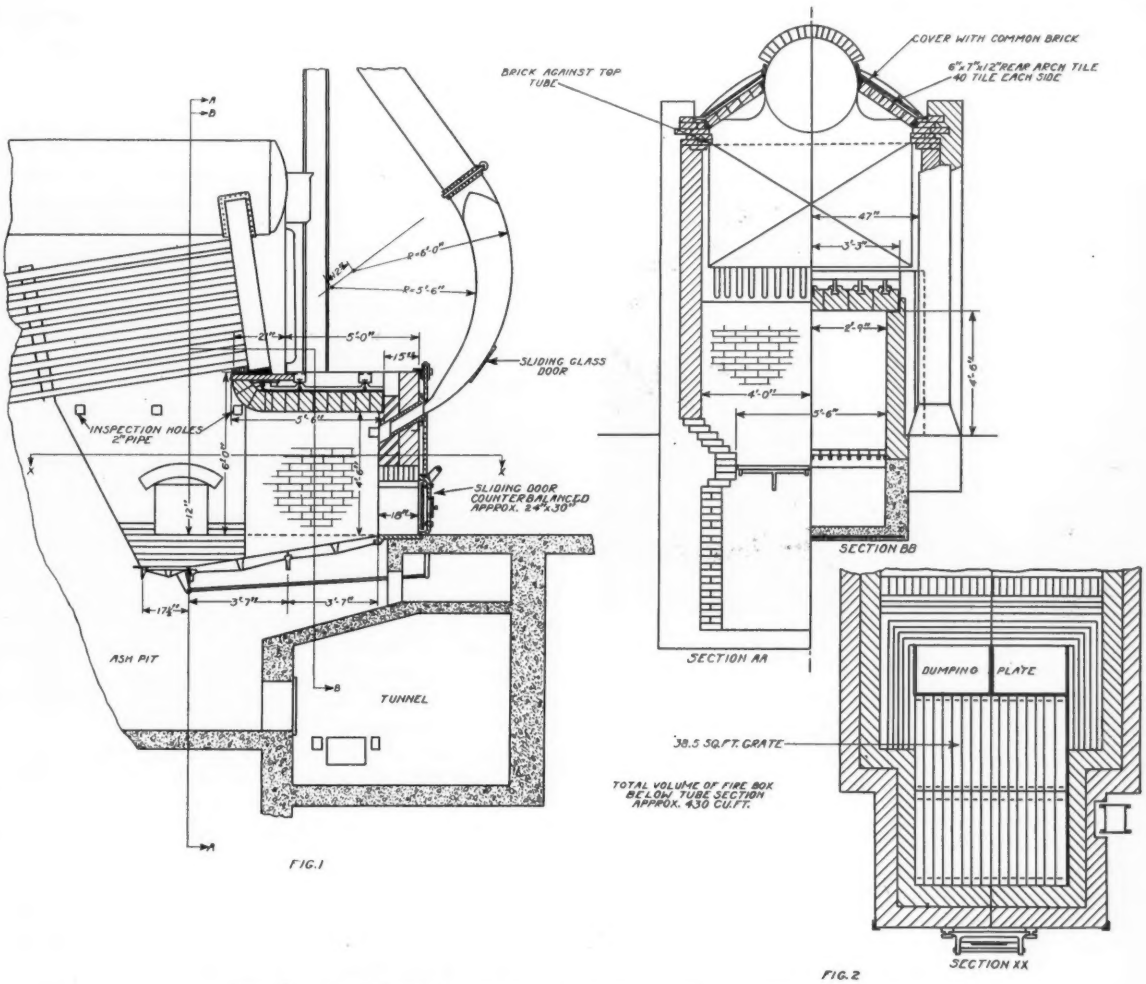


FIG. 1. LONGITUDINAL SECTION THROUGH WOOD-BURNING FURNACE
FIG. 2. CROSS SECTION AND PLAN OF WOOD-BURNING FURNACE

the boilers were there and the fireman could handle it without extra help, it seemed to be the way to solve the problem.

The matter of obtaining heat or to make steam from the refuse was a secondary consideration and whatever was gained was considered as all velvet. As the price of coal went up, however, and increased power plant efficiency was demanded, the question of obtaining more heat from the refuse was given consideration, especially in plants where the management and the engineers belonged to the progressive class.

As a result thereof, methods were developed and tried pipe or spout to the boiler furnace, where a bed of coal was maintained. As, in most cases, these dust pipes were of insufficient size to carry the shavings through without stoppage, the top of the cyclone was adjusted in such a manner that an air pressure was carried which helped to bring the shavings through the chute without stoppage, but at the same time an excessive amount of air was forced into the furnace, thereby reducing the efficiency of the combustion. It will readily be understood that this excess air not alone reduced the efficiency with which the shavings were burned, but also reduced the efficiency of the coal or other fuel used to a very

great extent. It is further obvious that as dry shavings will burn with much less draft over the fire than coal will, the draft that had to be maintained to burn the coal was too strong for the shavings and the result was, much of the wood particles were carried through the boiler and at times out in the stack before complete combustion was effected.

To prove the foregoing point, a test was carried out in a plant typical of wood-burning as described above. The boilers were horizontal return tubular set 4 or 5 ft. above floor level. On the first two days of the test, coal only was burned (hand-fired). On the following day, shavings only were burned, fired by hand. On the fourth day, coal was hand-fired and at the same time shavings were blown into the boiler through the dust pipe system as was the usual method during the operation of the factory. During all tests, the water fed to the boilers was measured and the fuel was weighed before being

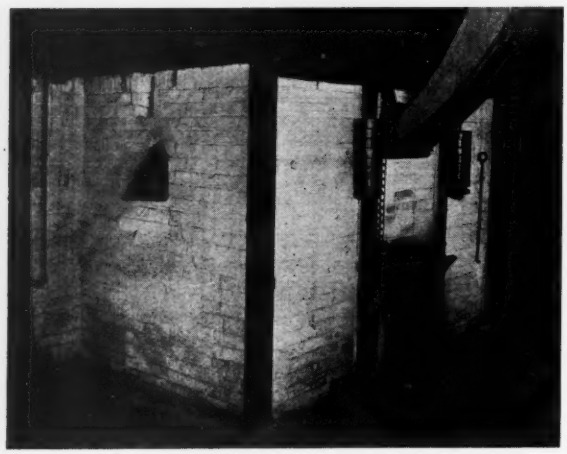


FIG. 3. DUTCH OVEN TYPE WOOD-BURNING FURNACE

fired. The coal was a good grade of Illinois egg coal, the shavings were principally mixed wood but well dried.

The results of the tests were as follows:

Test No. 1. Coal only. Evaporation per pound of coal, 7.5 lb. water.

Test No. 2. Shavings only. Evaporation per pound of shavings, 4.8 lb. water.

Test No. 3. Coal. Evaporation per pound of coal, 7.5 water.

Shavings. Evaporation per pound of shavings, 1.9 lb. water.

In computing test No. 3, it was assumed that the coal should give the same evaporation as when fired alone; this, of course, is not correct, but it does not change the total evaporation obtained; all it may change is the ratio of evaporation on coal and shavings.

From the preceding tests and other observations, it seems evident that coal should be burned by itself in furnaces constructed and operated for efficient coal burning and that shavings should be burned in furnaces constructed and operated for that purpose, always aiming to use the smallest number of boilers that will handle the shavings and operate those with a minimum of draft and excess air which will burn the fuel supplied and at the same time give safe operation. It is, of course, understood that the foregoing cannot apply where only one boiler is operated and both coal and shavings are burned.

The development of shaving burning has resulted in plants where shavings now are fed and burned efficiently by direct feed from cyclone or by mechanical feed devices; yes, even handled successfully on the chain grate stoker. Where mechanical means are employed, a shavings storage must be provided for in order to supply the boilers regularly regardless of the shavings received from the shops and this system is without doubt the most desirable. It is used in many plants, especially woodworking factories where more shavings are produced in the daytime than is required by the boilers during regular hours. The shaving storage therefore supplies fuel to the boilers during the night time when steam is used.

In other factories where the wood shop is only a part of the total factory, it is possible to take care of the shavings without a storage; one or more boilers are then arranged for burning shavings exclusively and the balance of the demand for steam is supplied from boilers burning coal only, the boilers burning shavings only operating during hours when shavings are produced, this giving an amount of steam during working hours somewhere proportional to the shavings produced by the wood shop (and to some extent proportional to the power consumed by the wood shop).

The writer is acquainted with woodworking factories where all the light, heat and power is produced from shavings only, the mill wood and refuse being sold. Plants with such efficiency are not frequently found, still they are bringing their owners a return on the money invested in them many times larger than the return on money invested in the factory proper.

In shaving burning installation, consideration must be given to the safety of operation; the possibility of ignition in the dust pipes or feeder device must be prevented. Precaution must be taken against dust explosions in furnaces and shaving bins; however, an explosion in a bin should not be used to condemn the entire installation or vice-versa.

The writer recollects a certain factory where the fireman went into the shaving bin with a lighted lantern to loosen shavings that would not slide down. As anybody can imagine, the fireman did not live to tell the sad tale, but it could not be blamed on the shaving bin nor the furnace installation.

Following is a description of a water-tube boiler which was rebuilt to provide means for burning of shavings and refuse efficiently as produced.

On Fig. 1 is shown a section through a 250-hp. Oil City water-tube boiler arranged with a furnace to take care of the shavings as they come from the wood shop and also provide a place to dispose of any combustible refuse with a minimum of labor in disposing of it. While it embodies some new ideas, it is a consolidation of several successful installations seen in operation but modified to suit local conditions. The grate is a herringbone pattern and is set at floor level in front, dropping 12 in. at the rear. This was done for several reasons: First, as the height of the boiler could not be changed it was necessary to lower the grate to obtain furnace volume; second, in making the front door flush with the floor level, it makes it very easy to dispose of refuse brought in by truck such as boxes, barrels, kegs, papers.

etc.; third, by slanting the grate downwards to the rear, added volume is given the gases as they expand.

The grate is 7 ft. long and has in addition a dumping grate in the rear which is 16 in. long and 5 ft. wide. A Detrick flat arch is suspended 5 ft. above the grate and is about 6 ft. long and the width of the furnace proper is 5 ft. 6 in. The arch together with the side walls form a heat storage which tends to ignite the fuel when the furnace is operating. Shavings are led from the cyclone through a pipe 16 in. in diameter which is carried on long radius curves without any branches or obstructions. The pipe runs into the feed chute, which, at its top, is 18 in. square and tapers down to a nozzle 18 in. wide and 4 in. high, which enters the boiler by means of a cast-iron chute 18 in. by 6 in., which is installed at an angle of 60 deg. and is a part of the furnace front.

This chute is equipped with a cast-iron balanced check which is held open by the air and shavings current as long as the shaving system is in operation; when this ceases, the check closes automatically, thus preventing any air from entering the furnace through the chute and at all times preventing any draft, heat or backfire from going from the furnace into the shaving system.

Figure 2 is a plan of the furnace. It is especially noted that the Dutch oven, which is only 5 ft. 6 in. wide, is increased to 8 ft. width under the boiler proper, thus increasing the furnace volume under the tube section, thereby decreasing the velocity of the gases in the first pass. The volume of the furnace under the tubes is about 432 cu. ft. and the grate surface excluding the dump grate 38.5 sq. ft.

A handle for the convenient adjusting of the draft damper is placed on the side of the Dutch oven and a draft gage placed right above the damper handle. The boiler is operated with a draft over the fire ranging from 0.05 to 0.20 in., according to the amount of shavings received.

For the firing of refuse, the furnace front has a sliding door 24 in. high and 30 in. wide, providing entrance for a box of that size or an ordinary size barrel without requiring any time in breaking up such refuse. This door is counterbalanced and equipped with baffle plate and air admission door.

The size of the furnace acts as an equalizer on the variation in shavings produced by the wood shop, at times of plenty a pile is formed on the grate and when less shavings are received this pile is burning down. When the furnace brickwork becomes hot, the smaller shavings burn in suspension, looking very much like an oil burner giving perfect combustion, and with the proper draft 15 per cent CO_2 is easily obtained on shavings and refuse only.

During the operation of the wood shop, this boiler "floats" on the line and produces steam according to the shavings and refuse obtained. When the wood shop shuts down, the boiler room attendant shuts the draft damper and the boiler retains its heat until the wood-shop is again started. Outside of the opening or closing of the draft damper, this boiler forms an automatic unit. It has an automatic nonreturn steam valve and an automatic regulating valve on the feed water line and will automatically cut itself in or out of the steam header according to the amount of fuel received. While no evaporation tests have been conducted with this boiler, the steam produced by it is very noticeable and the coal-burning boilers must be watched closely to keep the pop valves down when the "wood burner" is working. The total horsepower developed in this boiler room during the working day runs between 2000 and 3000 b.hp. in the winter time, in the summer somewhat less. The wood shop has as yet not been able to send over shavings faster than the boiler can burn them and the maximum amount this furnace can burn and turn into steam is still an unknown quantity. It is expected that this 250-hp. boiler will develop 400 to 500 hp. without any trouble if a sufficient amount of shavings is furnished.

Boiler Water---II

PRIMING, ITS CAUSES AND THEIR RELATIVE IMPORTANCE; CONTINUOUS DETERMINATION OF STEAM QUALITY. BY C. E. JOOS AND A. W. BINNS

ONE WOULD hardly attempt to contribute further to the subject of priming and the ills and woes of bad water, were it not for the fact that every operator encounters a set of conditions and circumstances slightly different from the next man; hence the experience of one may be valuable to the other.

Professor Fernald, in the introduction of his book, "Engineering of Power Plants," points to the fact that engineering, while based on an exact science, is not in itself an exact science, and that in practice, accuracy may mean within 20 per cent and not the seventh place to the right of the decimal.

Priming certainly belongs to this class. Tremendous variables enter which are hard to valuate. Figure 5 is an historical record of the several factors influencing priming. It is taken for a period of about 3 mo.

An ordinary A. S. M. E. standard throttling calorimeter was installed on each of the main feeders of the boiler house as shown in the sketch—Fig. 6. Before and after the orifice were installed the bulbs of a two-ten Tycos recording thermometer. The high curve is the temperature line before the orifice and the lower curve the temperature on the atmospheric side of the orifice.

A sample chart is shown in Fig. 7 and Fig. 8 shows the methods of obtaining quality.

For the purposes of comparison, however, we have counted the number of hours in the day that no priming occurred, and this figure has been plotted. As we have two feeders and two recording calorimeters, we have used the figure—Hrs. in 48 Free from Priming, as our index.

The load figures are average planimeter values from recording flow meters.

The concentration is a figure which we use and means the number of cubic centimeters of N/25 HCl required to neutralize 100 c.c. of boiler water.

Figure 5 is apparently full of inconsistencies. At points the priming gets better as the load goes up, which is a condition we would not expect.

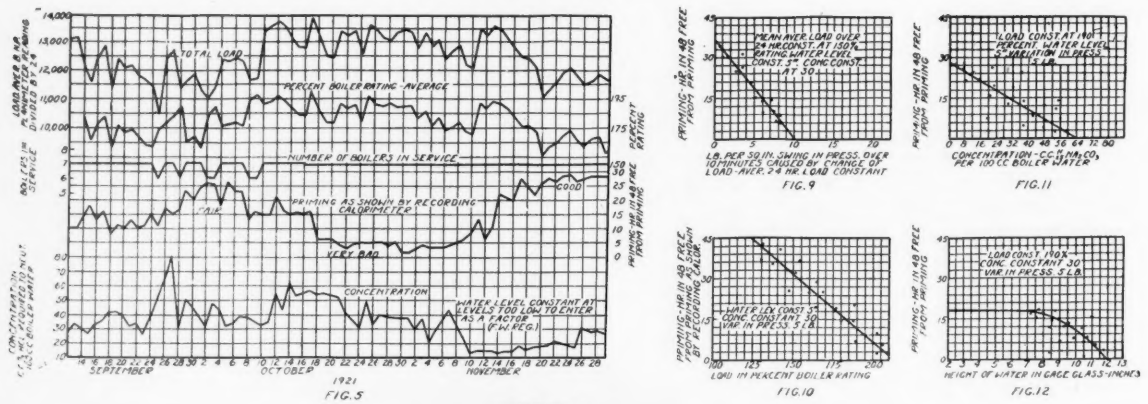


FIG. 5

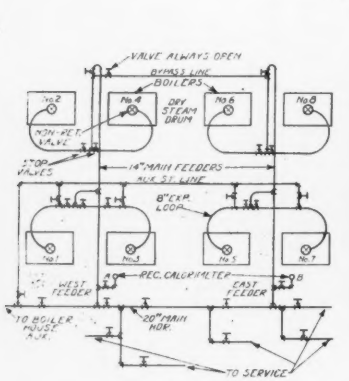


FIG. 6

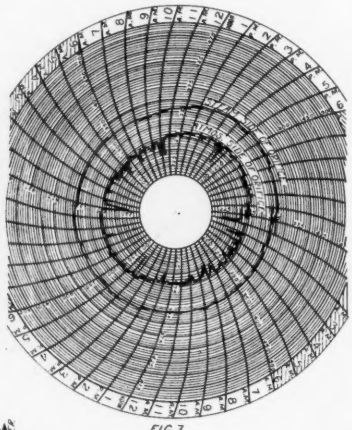


FIG. 7

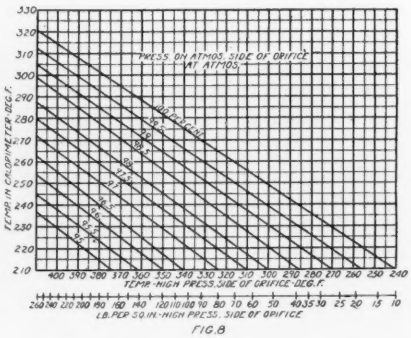

PRESS. ON ATMOS. SIDE OF ORIFICE AT ATMOS.
TEMP. IN CALORIMETER DEG. F.
TEMP.-HIGH PRESS. SIDE OF ORIFICE-DEG. F.
LB. PER SQ. IN.-HIGH PRESS. SIDE OF ORIFICE

FIG. 8

PRIMING-HP. IN 48 FREE FROM PRIMING
MEAN AVER. LOAD OVER 24 HR. CONST. AT 150% RATING. WATER LEVEL CONST. + CONC. CONST. AT 30
LB. PER SQ. IN. SWING IN PRESS. OVER 10 MINUTES, CAUSED BY CHANGE OF LOAD-AVER. 24 HR. LOAD CONSTANT

FIG. 9

PRIMING-HP. IN 48 FREE FROM PRIMING
LOAD CONST. AT 190% PERCENT. WATER LEVEL 2" VARIATION IN PRESS. 5 LB.
CONCENTRATION - CC. 5 N/10 CO3 PER 100 CC. BOILER WATER

FIG. 11

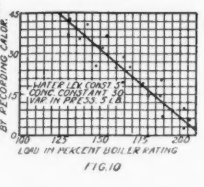

PRIMING-HP. IN 48 FREE FROM PRIMING AS SHOWN BY CALORIMETER
WATER LEV. CONST. 30 CONC. CONSTANT 30 VAR. IN PRESS. 5 LB.
LOAD IN PERCENT OF BOILER RATING

FIG. 10

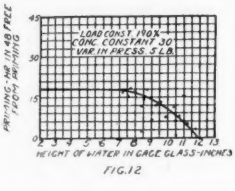
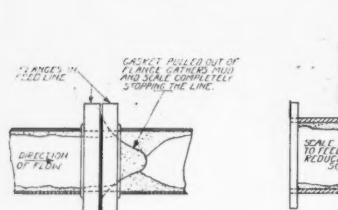


FIG. 12


GASKET PULLED OUT OF FLANGE, GATHERED MUD AND SCALE COMPLETELY STOPPING THE LINE.
DIRECTION OF FLOW
UNRAVELLING TYPE GASKET (OBSOLETE)

NOTE - THIS WAS THE CONDITION WHICH EXISTED IN THE ABNORMAL CURVE FIG 17.

FIG. 13

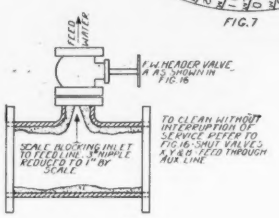

FEED WATER
F.W. HEADER VALVE A AS SHOWN IN FIG. 16
TO CLEAN WITHOUT INTERRUPTION OF SERVICE REFER TO FIG 16 - SHUT VALVES 3, 4 & 8 FEED THROUGH AUX LINE
SCALE BLOCKING INLET TO FEEDING TRIANGLE REDUCED TO 1" BY SCALE

FIG. 14

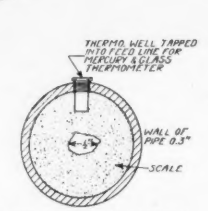

THERMO. WELL TAPPED INTO FEED LINE FOR MERCURY & GLASS THERMOMETER
WALL OF PIPE 0.3"
SCALE
SCALE ACCUMULATED AROUND SMALL THER. WELL ALMOST COMPLETELY BLOCKING LINE.
LOCATION OF WELL SHOWN AT 1 FIG. 16. ALL WELLS ARE NOW BEING REMOVED

FIG. 15

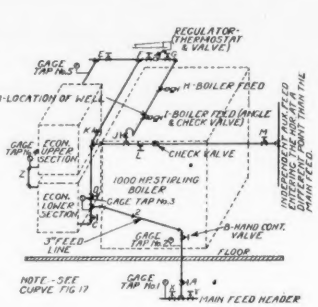


FIG. 16

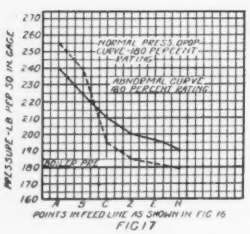

NORMAL PRESS. DROP CURVE 100 PERCENT RATING
ABNORMAL CURVE 190 PERCENT RATING
BOILER OUT
PRESSURE-LB. PER SQ. IN. GAGE
POINTS IN FEED LINE AS SHOWN IN FIG. 16

FIG. 17

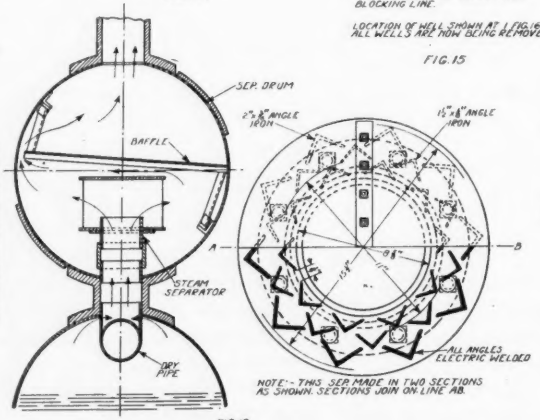


FIG. 18

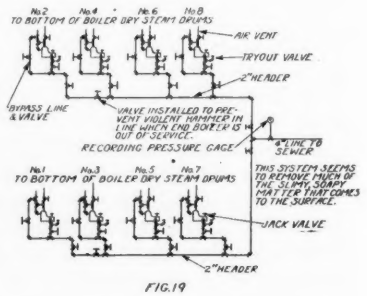


FIG. 19

FIG. 5. RECORD OF BOILER OPERATING FACTORS AFFECTING PRIMING. FIG. 6. DIAGRAM OF MAIN STEAM PIPING FROM BOILERS SHOWING LOCATION OF CALORIMETER AT A AND B. FIG. 7. TYPICAL RECORDING CALORIMETER CHART TAKEN ON MAIN FEEDER AS SHOWN IN FIG. 6. FIG. 8. CHART FOR DETERMINING QUALITY OF STEAM WITH THROTTLING CALORIMETER. FIG. 9. RELATION OF CHANGE IN LOAD TO PRIMING. FIG. 10. RELATION BETWEEN LOAD AND PRIMING. FIG. 11. RELATION OF CONCENTRATION TO PRIMING. FIG. 12. RELATION OF HEIGHT OF WATER IN GLASS TO PRIMING. FIGS. 13, 14, AND 15. CAUSES OF FEED LINE STOPPAGE. FIG. 16. DIAGRAM SHOWING GREAT FLEXIBILITY OF PIPING ALLOWING ANY PORTION TO BE CLEANED WHILE KEEPING BOILER IN SERVICE. FIG. 17. CURVES SHOWING USE OF PRESSURE GAGES AS SHOWN IN FIG. 16 TO DETERMINE POINTS OF STOPPAGE. FIG. 18. SECTIONS AND ELEVATION OF STEAM SEPARATOR. FIG. 19. TRAP LAYOUT SHOWING THE HIGH PRESSURE TRAPS INSTALLED TO DRAIN DRY STEAM DRUMS ON EACH BOILER

The loads as before noted are average planimeter values, hence a low average load might be a more changeable load than a load of high average, this as seen in Fig. 9, probably accounts for some of these inconsistencies.

We believe, however, that we are safe in concluding from this study that: With a boiler water concentration at 30, a load not in excess of 180 per cent rating, with a water level under half a glass (6 in.), and boiler pressures held within 5 lb. variation in 10-min. intervals,—fairly dry steam may be obtained.

This applies of course, only to our installation, but suggests the method of approach.

Factors Influencing Priming

We believe that there are four major factors influencing priming. We have attempted to show these factors diagrammatically in Figs. 9, 10, 11 and 12. This was done by varying the factor under consideration and holding the other factors constant.

These factors in their relative importance follow:

1. Change of Load.....70.
2. Load .....15.
3. Concentration .....10.
4. Height of Water in Glass..... 5.

These relative importances as we have noted them mean the relative importance under usual operating conditions; that is, any one of them may easily become the most important factor regardless of the other three. For instance, a concentration of 120 will cause excessive priming regardless of load, change of load or water level, and a water level of 12 in. will cause excessive priming regardless of the other factors.

We simply mean that under usual operation conditions these several factors are influential in the relative weights given them in causing priming.

As we have pointed out before, all these factors vary tremendously and the curves are only approximate. They are the results of our study, however, and we believe they are not far wide the mark.

Feed Water Troubles

The most serious trouble we have is the blocking of our feed lines. At least once a year, it becomes necessary to remove the entire feed line and turbine it out.

Figures 13, 14 and 15 are to scale and show the extent to which the line becomes blocked. In this connection, we have included a diagram, Fig. 16, of our feed line system which we feel is an excellent arrangement of piping, presenting great flexibility of control.

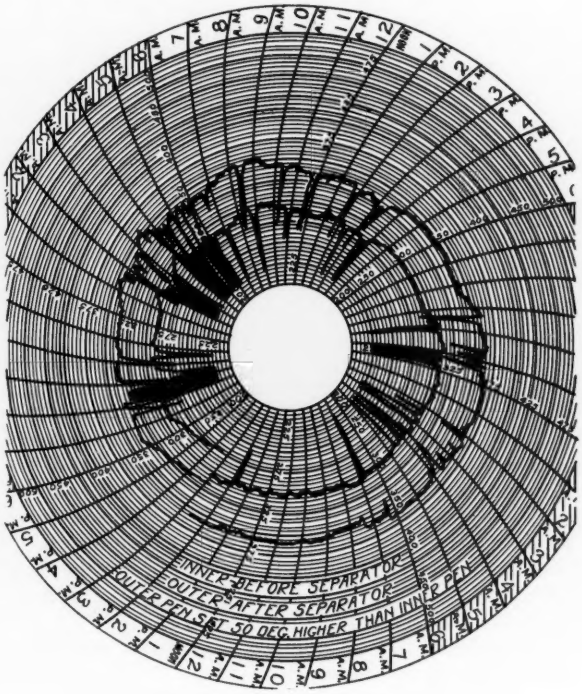


FIG. 20. RECORD OF TWO THROTTLING CALORIMETERS PLACED ON ONE CHART BEFORE AND AFTER THE SEPARATOR

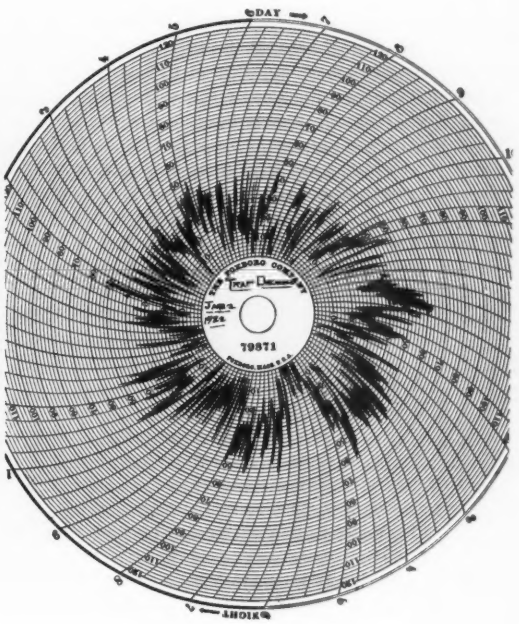


FIG. 21. RECORD FROM PRESSURE GAGE INSTALLED ON BOILER DRY STEAM DRUM TRAP DISCHARGE SHOWS ALL TRAPS HOLDING

By feed water troubles we mean mechanical troubles. The most serious consideration, of course, is scale in the boiler and we watch this very carefully. Every eight weeks, the boiler is turbined out and records kept of the total scale removed and the scale per 1000 hp.-hr. deposited.

All too frequently, on our heavy load peaks the water tender is unable to feed his boiler. We have tapped our feed line at several points in its course as shown in Fig. 16. With a clean line and a rating of from 175 per cent to 200 per cent, we get a normal pressure drop curve as shown in Fig. 17. This gives at the point of entrance to the boiler a water pressure about 10 lb. in excess of the steam pressure. Now, gradually more and more difficulty is experienced in feeding a boiler until the excess pressure drops out and the boiler is forced off the line.

Before this happens, however, we install our pressure gages and determine the point of stoppage. In this way, we get an abnormal pressure drop curve as shown by the broken line in Fig. 17. Where the abnormal curve is parallel to the normal curve, no trouble exists; but where the two curves cross, trouble may be expected.

In the illustration shown, clearly the trouble lies between B and C. In this particular case, a gasket had become unraveled and caught the sediment in the water, almost completely stopping the line. Figure 13 shows the situation.

Attempts to Obtain Dry Steam

What have we done to eliminate our priming? Well, we have tried hard and have met with some success.

On top of our Stirling boilers we installed a dry steam drum, so called. Next we designed and installed a separator of boiler plate and angle iron as shown with details in Fig. 18. This, together with our trap system shown in Fig. 19, removes some of our moisture; in fact, it breaks up the slugs and the heavy priming.

The chart, Fig. 20, shows the recording calorimeter bulbs installed on the atmospheric side of two throttling calorimeters—one placed before and one after the separator. The outer curve is after the separator and the inner curve before it. As will be seen, some of the heavy slugs are removed. The pens are set 50 deg. apart to avoid confusion.

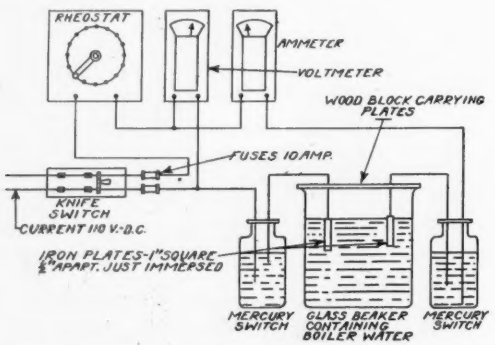


FIG. 22. DIAGRAMMATIC LAYOUT OF APPARATUS FOR DETERMINING CONDUCTIVITY OF BOILER WATER

Trap System

In connection with our trap system, we found some difficulty in keeping the eight 1½-in. traps shown in Fig. 19 in good working condition. They stood up much better than any other trap we could get even at that; the valves, monel metal though they were, would cut away like butter and allow the steam to blow straight through. To indicate this we installed a recording pressure gage on the main trap discharge line as shown in Fig. 19. If the traps are in good condition, they will at times be shut off and the pen will return to zero. If, however, there is a leak it will not come back to zero but to some higher point determined by the trap or traps blowing through. A sample chart is shown in Fig. 21.

In this connection, it may be interesting to note that as this is a 4-in. line, discharges into the atmosphere, and the length of straight pipe from the point at which the pressure is taken is known, a figure for the flow may be obtained.

Conductivity

Contrary to what might be expected, the concentration of the boiler water, within reasonable limits, enters as a minor factor. In water-tube boilers working at high ratings, the circulation is very rapid; in fact, little if any scale is deposited in a loose form which may be blown out at times of blowing down.

The only function of the blow-down is then to relieve the concentration. Every boiler does not work at the same rating and the concentrations cannot be equal.

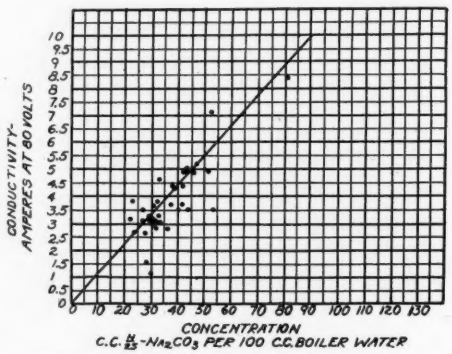


FIG. 23. RELATION OF CONCENTRATION TO CONDUCTIVITY OF BOILER WATER

The question which naturally presents itself is: Why not blow the boiler down when conditions demand and not at a time arbitrarily set?

We made the apparatus shown in Fig. 22. Figure 23 shows the relation between conductivity and concentration in the boiler waters under observation and with the conditions as we had them.

We would like to know what good reasons there are why the water tender should not read his concentrations from some central point, and then blow down the boiler when the concentration reaches some point, previously determined as the highest possible point.

We present this as a subject for thought and consideration among engineers.

United States Civil Service Commission announces examinations for junior physicist, May 24, July 5 and Aug. 23, to fill vacancies in the Bureau of Standards, Department of Commerce, Washington, D. C., at $1200 to $1500 a year, and in positions requiring similar qualifications, at these or higher or lower salaries. Appointees whose services are satisfactory may be allowed the increase granted by Congress of $20 a month. Competitors will be rated on general physics, mathematics through calculus, practical questions on an optional subject chosen from a given list, education, training and experience. Applicants must not have reached their fifty-fifth birthday on the date of the examination. This age limit does not apply to persons entitled to preference because of military or naval service. Classified employes who have reached the retirement age and have served 15 yr. are entitled to retirement with an annuity. Apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

Measurement of Superheat

TYPES OF THERMOMETERS USED; PRECAUTIONS IN TAKING READINGS; MAKING CORRECTIONS. BY B. O. SNYDER

THE USE of superheated steam is becoming more general wherever the economy of steam driven equipment is considered. In plants using superheated steam, it is important for the operators to know at all times how much superheat is really obtained and is of prime importance when making economy tests of steam driven units.

The problem of measuring superheat is not difficult, but if certain points are not observed large errors can be made.

There are three instruments in common use for measuring superheat: (a) the mercury and glass thermometer, (b) the mercury and metal thermometer, and (c) the electric resistance thermometer.

Of the three types the ordinary mercury and glass thermometer is the most commonly used, especially for making observations during economy tests. This type can be used for measuring temperatures as high as 575 deg. F., and can be made accurate to within 0.01 deg.

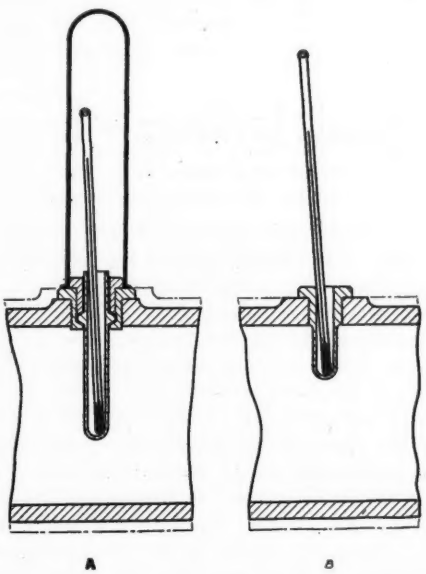


FIG. 1. CORRECT AND INCORRECT METHOD OF INSTALLING THERMOMETER IN STEAM PIPE LINE

For temperatures higher than the foregoing, special thermometers are made, having the space in the capillary tube above the mercury filled with nitrogen or carbon dioxide under pressure. The effect of this is to raise the boiling point of the mercury so that temperatures as high as 1000 deg. F. can be read. A special glass is employed in the manufacture of these instruments, which are generally too expensive for ordinary use.

The second type of thermometer, consisting of a metal bulb filled with mercury vapor and connected by a metal tube to some sort of indicating or recording dial, is generally used where a permanent fitting is desired. The operation of this type of instrument is based on the expansive force of the mercury vapor, which is employed to actuate the pointer on the dial. These instruments are made to operate the dials up to a maximum distance of 150 ft. from the bulb.

The third type of instrument is based on the increase of electrical resistance of certain metals with temperature, the indicating portion of these instruments being

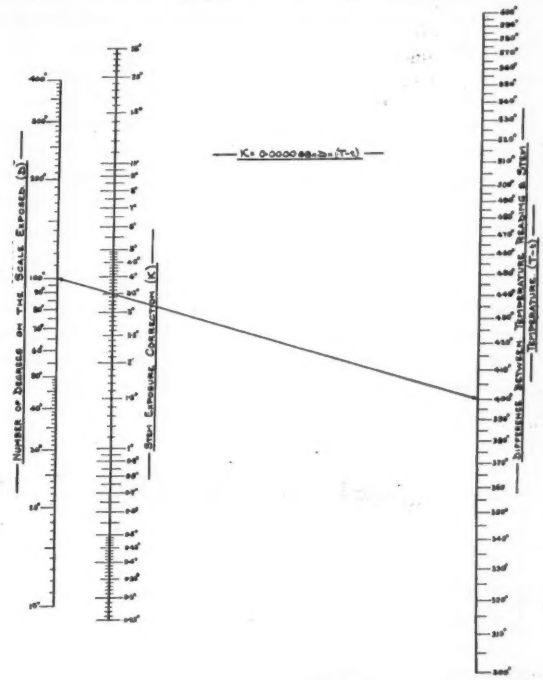


FIG. 2. CHART FOR DETERMINING CORRECTION DUE TO EXPOSED THERMOMETER STEM

some sort of galvanometer. These instruments can be used to measure temperatures up to 2200 deg. F. and are usually accurate to 0.01 deg. up to 500 deg. F. and 0.02 deg. up to 1000 deg. F.

The following remarks on the position of the thermometer apply equally well to all the above types. It is quite an easy matter to place the thermometer so that it will register anything but the correct temperature of the steam and it is often difficult to know when the readings are really reliable.

The thermometer should be placed so that the readings will not be affected by heat radiated from the boiler furnaces, nor must it be in a position where the colder parts of the machine will cause the reading to be low.

The bulb of a glass thermometer cannot be placed in direct contact with the steam unless specially constructed and calibrated for external pressures. Hot high pressure steam also has a corrosive effect on the glass and there would be mechanical difficulties in placing the instrument, which would not be desirable. It is customary, therefore, to place the thermometer in a thin steel cup or well partly filled with mercury or a good mineral oil having a high boiling point. The cup

should extend deep into the direct path of the steam; placing the cup anywhere but in the direct path may give as much as 60 deg. F. low reading.

The cup should be insulated from the vessel in which it is placed. Although the thermometer may give a correct reading at one point, it by no means follows that radiation and conduction from the fitting is constant at all temperatures. It is possible to introduce an error of 40 deg. F. in the reading, due to this point.

The exposed parts of the thermometer fitting should be lagged to avoid radiation; 10 deg. F. can easily be lost due to radiation.

The thermometer should be inserted in a cork stopper in the thermometer cup when no cover is fitted. Care should be taken that the thermometer does not float on the mercury when this liquid is used in the cup.

If possible the mercury in the thermometer stem should come just above the cork stopper, so as to avoid as much as possible a large "stem exposure" correction.

Figure 1A shows the correct way of installing the thermometer in position. Figure 1B shows the incorrect way.

When the thread of mercury in the stem is not at the same temperature as the bulb, as in the case of partial immersion of the stem in a thermometer cup without cover, a correction for stem exposure must be added. In practice it is usual to determine this correction as follows: Another thermometer is either tied to the stem of the instrument or is placed within a radius of 4 in. The correction is then calculated from the equation:

$$K = 0.000{,}088 \times D \times (T - t)$$

where:

K = stem exposure correction.

D = number of degrees on the scale exposed.

(T—t) = difference between the steam temperature reading and thermometer stem temperature.

Figure 2 shows a chart drawn from the above equation. By connecting the proper point on scale for D by a straight line to the proper point on scale for (T—t), the stem exposure correction K is given by the intersection of the straight line and the scale for K.

If reliable results are to be obtained not only should the precautions indicated above be observed, but the instrument should be calibrated from time to time, or, when making a test, before and after the test is made.

Thermometers are calibrated by comparison with a standard thermometer, or if this is not available, the thermometer should be sent to a laboratory doing this kind of work. There are usually laboratories within reach which will calibrate a thermometer for a small fee.

Before making a test, the position of the thermometer should be checked. This is best done by cutting out the superheater altogether and noting if the temperature of the saturation point of the steam and the thermometer reading agree for the observed pressure.

Cost Accounting System of Small Utilities---I

How the Town Board Discovered the Need for an Accounting System and the Way They Got One. By Mac Hanson

"THAT'S ALL the bills, Dan'l," announced Town Clerk Tom Johnston, Jr., to the mayor, Daniel Van Duzen, as he finished reading the bunch of claims against the town.

"I move the bills be allowed," spoke up Councilman Buck Orth.

"Second the motion," from Jack Louder, councilman from the Fourth Ward.

All in favor say 'aye,'" instructed Mayor Van Duzen, and the matter was carried unanimously.

"What else you got, Tom?" asked Mayor Dan'l, as the boys universally called him in friendly good humor.

Before we get too deep into official business let us get our locale clearly established. The little town of slightly under 1000 inhabitants was classed by state law, not as a town at all, but as a village. Consequently its official board members were not legally known as councilmen at all, nor its presiding officer as mayor, but as trustees and president of the board, respectively. In the pioneer days, when the town's site was virgin prairie, the cattle forded the creek at this point and the location was locally known as "the cattle ford." So, when a village sprang up, it was named Kineford by some wag, but pronounced, in later years, Kin-e-ford, with a short "i" as in "sit."

The town, at the time of our story, had five political wards. The other members of the board were Bill Stillman from the Second Ward and Doc Kidder from the Third.

"Any other business?" Mayor Dan'l inquired.

"Got a letter from the State Public Service Commission here," Tom replied, and he read it to the board. It was a request—which was tantamount to an order—for a comparative statement of receipts and disbursements and of balance sheets, covering the six months' periods from Jan. 1 to June 30 for the years 1919, 1920 and 1921 on the electric and water utility which the town owned and operated. A date limit of 30 days was given for the return of the completed report. Reference was made to the state law covering the making of reports and the penalties for refusal or failure to do so.

"What do you suppose they've got up their sleeve?" Buck Orth inquired of the group, which included the superintendent of the light and water plant, Bob Johnston; also Jim Fix, day marshal, and "Judge" Allen B. Slocum, town attorney.

"Don't suppose somebody's kicked to the commission on our rates?" Jack Louder boomed forth.

"There's lots of people kicking on their light bills being so high," Doc Kidder earnestly informed the board.

"Tell us something new, Doc," laughed Jack. "We can give him a whole book of that stuff, can't we, Buck?" and Louder turned to Buck Orth for confirmation. Jack and Buck were the light and water committee of the board. Everybody laughed. Kicking by the consumers on their light bills was an old story to all members but Doc Kidder, as he had only held his position for about a month, having been appointed to fill a vacancy. Being a natural-born kidder himself, Doc immediately tumbled to the point of the joke and joined the laughter.

"Do you really suppose somebody has applied to the commission for reduction in rates?" Doc asked half incredulously.

"Well, the darn fools! Don't they know they have to pay the expenses of this plant by its revenues, or else be taxed for it?" hotly inquired Bob Johnston, the superintendent of the light and water plant.

"I guess they haven't stopped to think of that side of it, Bob," Mayor Van Duzen laughingly remarked.

"I don't know, Dan'l," remarked Buck seriously. "I believe the people have a right to demand lower rates. They stood for a raise from 10c to 12c in 1917 and then to 15c in 1919. They didn't kick much then because everybody knew that coal and materials were high and scarce. But this is the summer of 1921. Coal is down a whole lot. We cut the superintendent's salary from $400 a month to $330 and materials are lower. Copper is a way off, isn't it, Bob?"

"Yes, wire doesn't cost us half what it did at the peak," Bob informed the board.

Buck continued: "My light bill at the house was $14.25 for last December and January, and Mary and I sit around in the dark half the time trying to keep the bill down. I think the people have a right to kick. I do myself."

"You've got nothing on me, Buck," Tom Johnston, clerk, spoke up as he paused in his job of writing out vouchers. "My bill was $15.85 for December and January and $15.20 for October and November preceding. I'm kicking, too."

"My bill was double then what it was the two months before," Mayor Dan'l chipped in. "But I have never said anything about it."

"My bill was pretty high, too," Jack Louder added to the general fund of information. "But, boys, we don't want to have this rate lowered for a while yet. If we could keep this rate for six months longer I believe we could get out of the woods and manage on a lower rate then pretty well."

"I say lower the rates right away. We can get by," Buck maintained his position.

Bill Stillman then spoke for the first time of the evening. "Somebody will have to make out that report asked for," he quietly remarked.

"That's the clerk's job," Jack loudly and pleasantly informed that gentleman.

"Go chase yourself. That's the treasurer's job," Tom rejoined.

"Let me see the blanks, Mr. Clerk," "Judge" Slocum requested in a slow nasal drawl. He looked at the last page of the blanks. "The president of the board has to swear to the statements contained herein," he slowly pronounced through his nose. "It looks like, Mr. President, that you are the proper official to make out this report."

"Wouldn't it be a daisy if I made it?" joked Mayor Dan'l.

"The honorable mayor has again been showered with the honors of his office, boys," laughingly kidded Doc Kidder. And everybody joined in with some facetious remark.

"Say, Tom! Is there anything more to come up?" Jack asked the clerk. "I've got to go to a church sociable."

"I want to go to that, too. Mary is waiting for me at the store now," Buck said.

"Who is going to make out that report?" inquired Tom.

"Let that go till next Monday night. We'll see then," Jack suggested. "I move we adjourn, Mr. President." And everybody got up and, after visiting awhile, left the board room.

While we are waiting for the next meeting night to roll around, let us look over the report blanks and study into the town's management of its municipal plant a little, so that we will have a better understanding of the situation.

Most states, by acts of their legislatures, have created public service commissions, or public utility commissions, or some board to govern public utilities such as electric, water, telephone, gas and street railways. These commissions or boards control rates and rentals, extensions, improvements, reductions, discontinuances, abandonments and mergers; set valuations, establish financial requirements and control financing; determine the amount of profits, depreciation and allowance for contingencies, both to be made and that are already earned; require cost accounting, bookkeeping, reports, inventories, balance sheets, income statements, etc.; all this as a source of information, both that they may check any unreasonable profits, or (let's be fair) undue losses, and that they may have the basis of facts necessary to render sound judgment when any utility applies for increases or decreases of rates, rentals or extensions. But, then, most of you know much more about these things than I do.

In our state the public service commission requires annual reports from all utilities. These reports are to be made out on forms furnished by the commission. The forms, in booklet style, are the most complete, best arranged, scientifically prepared statements that the certified public accountants of the commission could devise. When properly filled out, they give a thorough, comprehensive display of every financial transaction of a utility.

But, as a former clerk once complained to me, "It's an outrage for a $75-a-year clerk to be asked to fill in a set of blanks prepared by a $5000-a-year certified public accountant."

These blanks require, first, a recapitulated income statement, setting forth the revenues received from each source, the expenditures incurred by each department of the business, the disposition of the net earnings, and the surplus or deficit accrued. The items for this recapitulated income statement are drawn from a detailed, itemized statement of operating expenditures by departments of the business, which statement of expenditures is the second requirement.

The departments of the business established by the commission for a "Class C" utility, which is our classification, are, Power, which includes the expenses of the boiler room and machinery room; Transmission, which covers the expenses of transmitting the high-voltage current; Distribution, which covers the expense of distributing the low-voltage current to consumers; Consumption, which takes in the expenses of trimming and inspecting lamps, lamp maintenance, renewals, etc.; Commercial, which covers the expenses of meter reading, collector's salary, etc.; General, which includes general office sal-

aries, supplies and expenses, and general office maintenance; and Deductions From Gross Income, which covers interest on funded debt, mortgage debt, and on floating debt, etc.

Also, a statement of depreciation, contingencies, and taxes expense figure in the report. And besides this a statement of nonoperating revenues and nonoperating expenditures is required in the income statement, and those two are the third part of the report.

Then follows an itemized statement of the "steam generation apportionment account," showing what part of the steam generation expenses are charged to the electric utility and what to the water utility; a capital stock statement; a funded debt statement; a depreciation statement; a depreciation reserve account statement; a materials and supplies stock statement; a summary of employes and wages; a summary of central station equipment; a list of commercial consumers by kinds of business; a load data sheet; a list of statistics of power generation, etc., etc. And worst of all, a balance sheet.

Looks like that former clerk was right, at that, doesn't it? And that's not all there is to it. Figuring out the unit costs per kilowatt-hour of each department is no small job. But, I'll say this, if this report is filled out with any accuracy at all, then the commission has the complete and necessary data to determine whether a petition for increase or decrease of rates should be sustained or rejected; whether extension of service should be permitted; whether curtailment of service should be ordered; or whether abandonment should be considered.

You can readily see that, in order to fill out this report with any semblance of accuracy, some form of cost finding, no matter how crude or simple, is an absolute necessity. I want to tell you how our town ran a bluff of making out their reports heretofore; how the town board finally realized that they must have a cost accounting system; to explain the system finally worked out, so you can use it to guide you in your like endeavors; and to enumerate the advantages and results obtained from this cost accounting system.

Now let us see how the town filled out this report prior to Dec. 31, 1921. When the first blanks were received, following the passage of the Public Service Commission Act by the legislature some 8 or 10 yr. ago, the town clerk, who happened to be Tom Johnston, Jr., at that time, brought the blanks before the town board. Every person present looked at them and, with a blank expression on his countenance, passed them on. Nobody understood them.

They might as well have been written in Greek. No records of any kind were kept from which to gather the data required except the clerk's record of bills or claims allowed, and the treasurer's records of receipts and disbursements of the light and water fund.

The board instructed the clerk and superintendent of the plant to do their best at filling them in. The clerk drew off the total expenses for fuel, oil, labor, supplies, interest and salaries and blindly apportioned them to the various headings on the blanks. The superintendent made a wild guess at the number of kilowatt-hours of electric current produced during the year and the number of gallons of water pumped annually (for the plant had neither electric or water meter) and together the superintendent and clerk filled out the unit costs required. The balance sheet was purely and wholly a bluff. The report was sent in, and was never returned for correction! This system of reporting was used from then on until after the annual report of 1920 was made. Tom was employed each year to help the clerk or treasurer, as the case happened to be, to make out the report. And no report was ever returned for correction!

The reason for this no doubt was solely because the plant was a municipal utility and nobody had ever applied to the Commission for reduction or increase of rates or for other purposes, except the town itself in 1917 and 1919, when it applied for increases. As there was no objection at either time by any consumer, the Commission granted the increases due to the increased cost of materials and labor during those years.

It doesn't make so much difference to the Commission or to the local community when the utility is a municipal utility. If it is a privately owned utility, then the matter is different. But a municipal utility has two sources of meeting the expenses of its plant,—from its revenues for services and from taxation. Theoretically, the same people are paying the revenues and the taxes. If the revenue rates are low, then the tax rate will have to be high in order to get the total amount of funds necessary to run the plant; but if the revenue rate is high, then the tax rate can be lower. The people are paying the expenses of their plant out of two pockets,—the right-hand pocket and the left-hand pocket. If one pocket pays more, the other can pay less; but it all comes from the same man anyway.

But when the Commission in the early summer of 1921 required a comparative report in parallel columns for the six months' periods of 1919, 1920, and 1921, and in looking up the town's copies of reports for these years, it was discovered that the 1919 report was lost, then the matter came to a head. The subject came up again at the next board meeting on the following Monday evening.

After the reading of the minutes, allowing of claims, reading of correspondence, etc., had been completed, Tom inquired, "What are you going to do about that comparative report?"

"What! Haven't you got that made out yet?" Jack Louder laughingly joked.

"We'll have to deduct a month's pay from the clerk's salary for gross negligence of duty," kidded Doc Kidder. The clerk's salary was $10 a month.

"Boys, we've got to do something," Tom earnestly continued. "The 1919 report is lost. That's nothing to mourn about, though, for those reports weren't worth a darn, anyway. I ought to know. I helped to make them all out."

"What's your idea, Tom?" inquired Mayor Dan'l.

"It's my idea that nobody has applied to the Commission for reduction of rates. I think the Commission merely wants data to determine whether the town is still entitled to the rates granted under its last order. They can't tell, and nobody else can tell, from those reports we sent in. What this town needs is a cost accounting system for its plant."

"I've thought that way about it for quite a while," Jack Louder said.

"Yes, and I've felt that way about it ever since I've been running the plant," Bob Johnston broke in. "We don't even know what it costs us to pump water or generate electricity even as an annual total."

"Can you work out a cost system, Tom?" inquired Bill Stillman, who had been quietly listening to the conversation.

"I believe I could," Tom dubiously answered. "I've been thinking about the matter."

"Will you do it?" Stillman continued.

"Listen, Bill. That's going to take a lot of study and a lot of planning and figuring. Any cost system worked out ought to be of such a form that totals can be drawn directly from it to fill the annual reports required by the Commission. I don't exactly feel that I ought to be expected to devote that much time and study to it for the princely salary I'm receiving."

"What would it be worth to you to design such a set of forms?"

"Well, I hadn't thought of it. But I'll do it for,—say $25," Tom hesitatingly replied.

"What do you think of it, Dan?" Bill inquired.

"Be money well spent, I think," Dan'l answered.

"I don't think we ought to spend any money for that purpose," Buck spoke up. "We're short on funds, anyway. Can't you and Jack and I come down here some day and run that report up, Tom? I'd be willing to devote a half-day to it."

"I'll do my share," Tom agreed; and so did Jack.

"I don't see that cost accounting would do us any good anyway," Buck continued. "The treasurer's reports show us how much we spend each month and how much is received. That's all a cost sheet would tell you." Buck was strong on saving money. His idea was that if you didn't spend it, you had it. Those of you who live in small communities know that I speak truly when I say that the small town business man doesn't get ahead by making money, but by saving money. And this idea becomes a habit, which habit soon becomes an ingrained part of his nature, so that, many a time, he saves a penny but loses a pound.

Buck's slighting remark about the value of cost accounting roused Tom's ire. It should, probably, be stated that Tom, himself, who was in a manufacturing business, had never had a cost accounting system in his own business until about 4 yr. when he was forced by disastrous circumstances to adopt a system. He had formerly gotten by, like all small town business men, mostly because luck was with him and he had been raised in the business and knew, in a general way, what his selling prices would have to be, to get him a profit.

But a few years ago he had taken a big order—big for him—for a new line of products. He had figured the costs on this new line as all small merchants generally figure. He had counted up his labor, material costs, fuel, oil, interest charges and allowed 10 per cent for "unforeseen" expenses and had added 10 per cent for his profit. He had gone along all summer thinking he was making a lot of money; but when the job was completed and he was cleaning up his debts, he found that he was $3000 short of enough money to meet them. This scared him and he spent six weeks in going over his checks and such records as he had to find out what was the trouble. From this information thus gained, he worked out a cost system for his business.

"So you think a cost system don't amount to a darn, do you, Buck?" Tom heatedly inquired. "Let me ask you a few questions. Does the treasurer's report tell you how much money was spent for fuel, how much for oil, for labor, for supplies, for interest? Does it show you what depreciation there was on the buildings, the machinery, or the lines? Does it give you any idea how much was spent for operation and how much for maintenance? Does it tell you what it cost to produce a kilowatt-hour of juice or a thousand gallons of water? Does it split the costs between the boiler room, the power room, the transmission and the distribution system? Does it tell what per cent of the cost of steam should be charged to water and what to electricity? Does it even tell you the total cost of steam so you can compare that item from year to year and see whether it is increasing or decreasing and why? Or so you can compare your costs with other power plants' costs and see whether you are higher or lower and why? Does it show you what, if any, costs are excessive and why they are and suggest how you can lower them? Does it tell a thousand and one things that a manufacturer ought to know in order to hold down his expenses? If it does, then you don't need a cost accounting system." And Tom stopped for breath.

"Now, Tom, I didn't mean to insult you," Buck laughingly replied. "I was just expressing my views. If the rest of the board think we ought to have a cost system, I'm not going to kick."

"This board is spending other people's money," Tom continued, "and I believe those other people have a right to expect us to spend it intelligently. You know as well as I do, that every board heretofore has always allowed all bills the superintendent brings in, if he has received the materials called for. The boards never know what the materials were used for or whether they are really needed. A cost system would put the expenses of the plant under control of the board," Tom said.

"I believe it's the right thing, Mr. President," Jack said. "I move that the board instruct the clerk to work out a system of cost accounting and be allowed $25 for his services." And so a radical change for the better was thus established in Kineford's municipal plant.

Now Tom had said that he had been thinking of such a system. He had been reading a booklet published by the Commission entitled "Cost Accounting for Electric Utilities." During the next three or four weeks, as he found time at his office, he worked on this cost system. By frequent consultations with the superintendent of the light and water plant, by several readings of the booklet, and by several plannings of forms and destructions of them as unfit, he finally worked out a set of forms. In later articles we will take up these forms and explain them in detail.

TWO LICENSES of unusual importance were authorized recently by the Federal Power Commission. The Southern California Edison Co. was granted a license to develop an important project on the San Joaquin River. It is planned to install machinery capable of developing 195,000 hp. A dam 100 ft. high is to be erected. The power will be fed into the company's transmission line which supplies power to Los Angeles. Another license was granted the Portland Railway Light and Power Co. of Portland, Ore. This covers important developments in Clackamas County, Oregon.

SOME PEOPLE win success because they are able to cover up misplays.

Combustion Engines

Starting Up, Shutting Down and Routine of Operation

BEFORE trying to start up, in case any repairs or overhauling have been done, the engine should be turned over a few times by hand to make sure that all parts are working freely. For small engines, it is usual to turn them over by main strength until the engine fires, or in case of explosion engines, to turn them back against compression, after getting a charge of mixture into the cylinder, then release quickly, as the charge is fired. For larger sizes, some mechanical starting method is provided, an electric motor geared to the flywheel rim or compressed air stored in receivers and turned into the power cylinder by special starting valves.

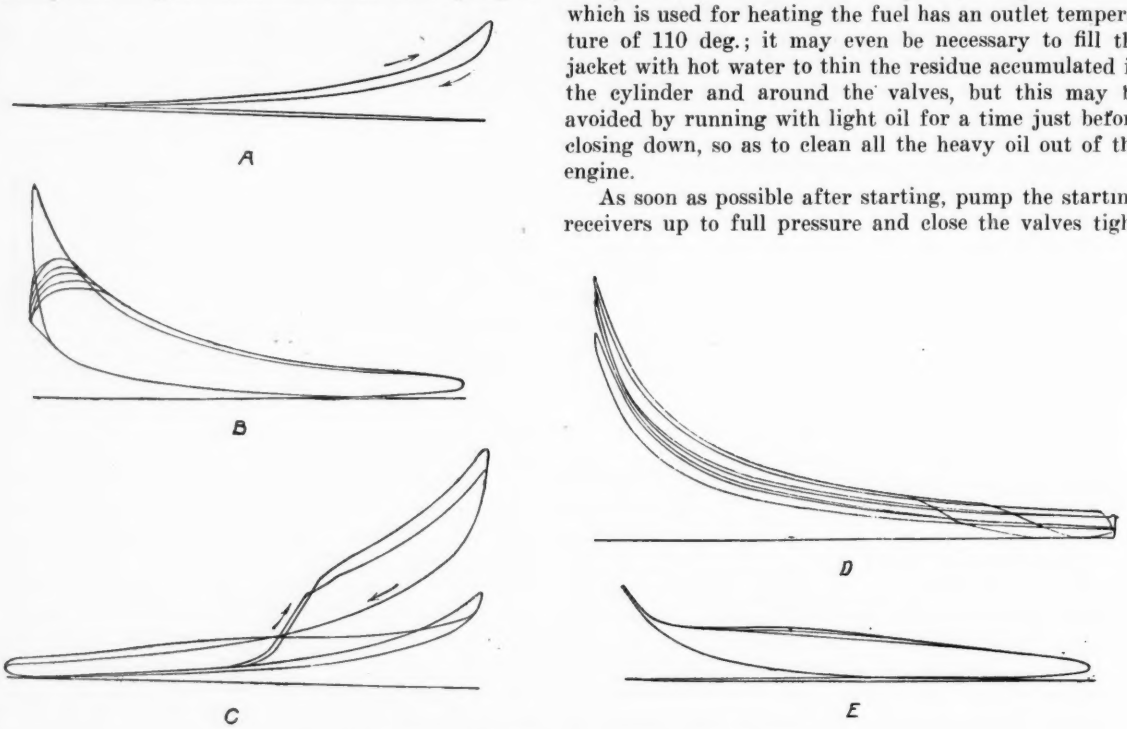
In either case, careful examination should be made of all valves and mechanism of the engine to be sure that they are in good condition before attempting to start. So far as possible, valves and the governor control, and in every case injection and ignition should be tested by hand to see that they will work correctly; fuel supply should be inspected to make sure that it is ample and the system full up to the admission valves or mixing devices; if air is used to start, be sure that the receiver is up to pressure (200 to 300 lb.) and for Diesel engines that the injection air is at full pressure of at least 100 lb. higher. If it is a multi-cylinder engine using part of the cylinders only for the air starting, make sure that the engine is in such position that the proper cylinders will get air when it is turned on, then turn the engine to full starting position.

In order to avoid overheating when starting, the cooling water should be turned on and the circulating pump primed. Fill the lubricators and open the valves to bearings and cylinders so that full flow of oil will start at once. For an engine lubricated by the "splash system," inspect the oil level through the "feed hole" before starting.

Having made sure that everything is in good condition for a start, set the starting-air valve to the "start" position and the air inlet valve to the low-pressure compressor wide open. Finally, open the valve from the starting-air receiver and when the engine is up to speed, close the starting-air valve and open the fuel injection valve wide.

When the regular fuel is a heavy oil that has to be heated, lighter oil must be used for starting and the heavy oil should be turned on only after the jacket water which is used for heating the fuel has an outlet temperature of 110 deg.; it may even be necessary to fill the jacket with hot water to thin the residue accumulated in the cylinder and around the valves, but this may be avoided by running with light oil for a time just before closing down, so as to clean all the heavy oil out of the engine.

As soon as possible after starting, pump the starting receivers up to full pressure and close the valves tight so that air may be on hand to start in case of an unforeseen shut-down.



INDICATOR DIAGRAMS SHOWING IRREGULAR ACTION

Failure to start readily will probably be due to improper action of the starting valve, leaking valves or piston rings resulting in low compression, failure of the fuel to reach the spray nozzle, or low pressure of the injection air. Each should be investigated in turn. Time should be allowed to start slowly and carefully, warming up well before throwing on load. Quick starts are liable to cause trouble and may even result in cracked cylinder heads due to unequal expansion.

Shutting Down

It is best, if possible, to throw off load gradually thus permitting gradual cooling of the cylinder. If a

quick stop is unavoidable, cut off the fuel and let the engine stop with the load on. It is well to dose the exhaust valve stems with kerosene before stopping to cut the gummed oil, especially if the fuel has an asphalt base or is a heavy oil. As already mentioned, changing to a light oil before stopping will clear out the engine and make the next start easier, and if the regular fuel contains sulphur, this will help to avoid corrosion.

For a regular stop, shut off the fuel, open the bleeders on the air compressor as the engine slows down, and when almost stopped, shut off the injection air. After stopping, close off the lubricators and make sure that the valves to the starting and injection air receivers are closed tight.

Most authorities advocate allowing cooling water to circulate after the engine has stopped, to cool the parts and prevent the oil from thinning so as to drain away and break the oil seal between the pistons and the cylinder walls; also to avoid leaving the wristpins dry. Too much heat after stopping may fry the oil on the piston rings so that they will be gummed and stick, and where salt water is used for cooling, leaving hot water in the jackets may result in precipitation of the salt and clogging of the passages.

Other authorities state that leaving the cooling water on causes too rapid cooling of the cylinder and head, with uneven contraction and possible cracked cylinder heads; but this can probably be avoided by leaving the water on and retarding the circulation so that the temperature of the outlet water will fall only slowly. If the engine is exposed to freezing temperatures, all water should be drained off after the circulation is stopped. It is well to blow out the intercooler coils of the high-pressure air compressor after shutting down to make sure that they are free of dirt and moisture.

As soon as possible after shutting down, valves, governor gear, pumps and other parts that can be moved by hand should be gone over to make sure that they are working freely so that there will be no delay if an emergency start is required. Fuel tank and lubricators should be examined and filled, if necessary, pressure in starting and injection air receivers verified and the engine turned so as to be just back of starting position, so that the starting valve will not be held open, thus avoiding possible corrosion of the valve stem, while permitting of quickly bringing the engine to full starting position.

Operating Routine

Points to be watched while the engine is running are: regularity and vigor of firing, leakage in fuel water or air systems, noise due to wear of bearings, noise due to irregular action, the regular functioning of cooling and lubricating systems, compression and air pressures.

For the explosion type, ignition may be too late or too early, the former usually causing overheating and the latter a metallic knocking. Timing of the spark should be shifted gradually until the engine runs easily. Usually the best economy is secured by keeping the spark advanced as far as possible without causing knocking.

In Diesel type engines the time of injection may be altered slightly, but should never be set earlier than the limit given by the builders, as the oil will begin to burn before compression is completed causing knocking and loss of power. Usually best results are had with firing timed for crank position 9 deg. ahead of the dead center, but to allow some margin of safety it is usually set for 7.5 deg. ahead.

Leakage of fuel past the valve or around the valve cage may cause a preignition effect the same as too early timing by allowing some oil to enter before compression is completed. Even if this is not sufficient to cause knocking, it will cause high pressure while the crank is turning the center resulting in excessive wear on bearings.

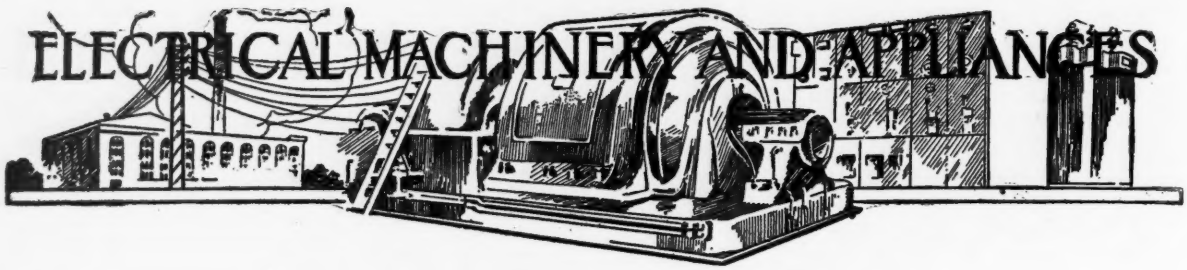
To get even firing and smooth working, it is essential that all cylinders of a multicylinder engine have like fuel charges the same compression pressure and like timing. These matters should be checked frequently by using the indicator or a compression gage, testing the timing and intensity of the spark, the delivery of fuel pumps, clearance of valve-lifting cams and lift of valves. For light-oil explosive engines, the compression should be maintained at 75 to 90 lb., for gas at 100 to 150 lb., for medium oils in Diesel engines at 400 to 500 lb. and for heavy oils somewhat higher up to 700 lb. Lower values than these may be tolerated for a time so long as all cylinders have the same compression, but less than 350 lb. in Diesel engines will result in slow firing and loss of power.

Test of compression is made by shutting off fuel or spark in one cylinder at a time, and measuring the maximum pressure by means of an indicator diagram or by a registering gage. For a one-cylinder engine, bring it to speed and then shut off the fuel, testing the compression while the engine is running by inertia.

The lift of valves should be at least one-quarter the diameter of the seat and should give a velocity through the opening of 70 to 100 ft. a second. Clearance between cam and push rod ranges from 1/32 in. for large sizes to 0.005 in. for small high-speed engines; the least which will permit full seating of the valve is best.

Study of indicator diagrams, which should be taken every week, will often reveal irregular action and the diagrams of Fig. 1 taken from Dubbel give an idea of how such irregularities are shown. A is a compression diagram, but the expansion line falling considerably below the compression line indicates leaking piston rings. B, from a producer gas engine, indicates somewhat slow burning of the charge with one stroke in which preignition was caused by unburned fuel remaining in the cylinder. C, from a double-acting engine, was caused by leakage past the piston sufficient to ignite the charge during compression and to raise the pressure during exhaust and admission. D shows very clearly preignition from the hot carbon deposits indicating dirty pistons and valves. E is caused by late ignition, combustion taking place after the piston has started forward. While these diagrams are from Otto type engines, indications will be similar for the Diesel type except for the card C which could hardly occur in a Diesel engine.

Air pressure should be watched carefully in a Diesel engine. If injection pressure falls too low, it will result in a smoky exhaust because the fuel will not be finely atomized. If pressure gets too high, fuel will be supplied so rapidly as to produce a partially explosive effect resulting in knocking.



Battery Charging Apparatus

BOOSTERS, THEIR CONNECTIONS, RATINGS AND CAUSES OF FAILURE. BY H. M. PHILLIPS

ALTHOUGH it is always possible to utilize a motor-generator set for battery charging, the booster set has a distinct advantage in both first cost and economy of operation when the charging voltage is higher than that of the supply line. The booster, which is usually motor driven, is merely a low voltage generator so connected as to add its voltage to that already existing in the main line.

As an illustration, we may assume that there is available a 115-v. power circuit for charging a battery of 60

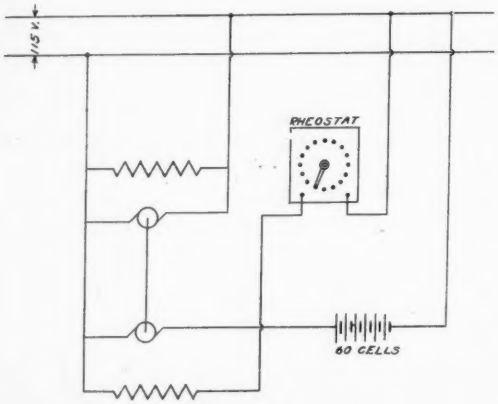


DIAGRAM OF CONNECTIONS FOR CHARGING STORAGE BATTERY WITH BOOSTER

cells; the charge to commence with 100 amp. at 120 v., to maintain the 100-amp. rate up to 135 v., and to complete the charge at 50 amp. and 150 v. The booster set would then be connected in circuit as shown in the diagram. The booster in this case would have an output of $100 \times (120 - 115) = 500$ watts or 0.5 kw. at the beginning of charge; $100 \times (135 - 115) \div 1000 = 2.0$ kw. at the end of the 100-amp. period; and $50 \times (150 - 115) \div 1000 = 1.75$ kw. at the end of the charge. The output of a motor-generator set for charging the same battery under the same conditions would be $100 \times 120 \div 1000 = 12$ kw., at the beginning; $100 \times 135 \div 1000 = 13.5$ kw. at the middle period and $50 \times 150 \div 1000 = 7.5$ kw. at the end. The size of the motor in each case would be determined from the maximum generator output, making a proper allowance for the efficiency in each case. On account of the larger size of the units and higher voltage of the generator, the motor generator set should have a slightly better set efficiency than the booster, assuming an over-all efficiency of 80 per cent for the former and 60 for the latter, the total power lost while operating the motor-generator at maximum capacity will be $13.5 \times \frac{0.20}{0.80} = 3.37$ kw., while the total power loss for the booster set is $2.0 \times \frac{0.40}{0.60} = 1.33$ kw. The booster generator, or other very low voltage generator, may be recognized by its abnormally large commutator; in the illustration, the 2.0-kw. booster must carry and commutate the same amperage as the 13.5-kw. generator; this makes the booster a somewhat more expensive machine than one of the same kw. capacity at a higher voltage, but it is far cheaper than the 13.5-kw. generator of the motor-generator set.

The booster may be used to decrease the line voltage as well as to increase it. By placing a reversing switch in the field circuit of the booster its polarity is readily reversed; when, with armature current in the same direction as before, it becomes a motor, running at somewhat higher speed than before and sending the power generated back into the line by driving its motor as a generator and pumping current back to the line. On account of the higher operating speed and the fact that voltage lost in overcoming armature resistance increases instead of diminishes its terminal voltage, the booster operated in this manner is capable of diminishing the line voltage to a slightly greater extent than it can raise it when acting as a generator. In fact, the booster would show its greatest advantage over the motor generator set in charging a battery of 52 cells, beginning its charge at 100 amp. and 104 v., continuing the 100-amp. rate up to 117 v. and finishing at 50 amp. and 130 v. Under the above conditions, with a 115-v. supply line, the charge would begin with the booster acting as a motor with an input of $(115 - 104) \times 100 \div 1000 = 1.1$ kw.; at the end of the 100-amp. period it would be acting as a generator with an output of $(117 - 115) \times 100 \div 1000 = 0.2$ kw.; and at the end of the charge as a generator with an output of $(130 - 115) \times 50 \div 1000 = 0.75$ kw.

Although the booster may readily be used for reducing voltage, the advantages derived from its use are less marked than when being used to increase the voltage. Take as an illustration a battery of 46 cells, with the same charging conditions as before. The maximum input is now $(115 - 92) \times 100 \div 1000 = 2.3$ kw., of which

60 per cent may be returned to the line, leaving an operating loss of 0.92 kw. This would be a very decided improvement on a motor-generator, whose maximum output would be $46 \times 2.25 \times 100 \div 1000 = 10.35$ kw., but a charging rheostat would probably be preferable to either on account of lower first cost and lessened liability of accidents. There would be a power loss of 2.3 kw. at the beginning of the charge, but this would diminish quite rapidly as the charge progressed and fall to zero at the end of the charge; while the 0.92-kw. operating loss of the booster would not vary greatly during the entire course of the charge. Reducing the number of cells to 30 gives a maximum booster input of $(115 - 60) \times 100 = 5.5$ kw., against a maximum motor-generator output of $30 \times 2.25 \times 100 = 6.75$ kw.; the advantage, still in favor of the booster, being partially offset by the wider range of voltage obtainable with the motor-generator. For a lesser number of cells, the advantage would generally lie with the motor-generator.

It is rather interesting to trace the probable results that will follow the various accidents that may occur in service; safety devices, such as fuses; circuit breakers arranged for over-load, under-load, low voltage, or reverse current release, or a combination of two or more of these, should be provided where in the engineer's judgment, the additional complication and expense is justified. A short circuit on the battery circuit has the immediate effect of causing a heavy overload in the booster armature; if this is not immediately interrupted, further developments will depend upon whether the booster is acting as a generator or a motor and upon the voltage it is generating at the time of the accident. It should be noted that as the battery circuit is direct connected to the line, a ground may produce a short circuit that will not be interrupted by a single pole circuit breaker. With the booster acting as a generator, and with fields fully excited, the excessive armature current produces a heavy overload which is transmitted to the motor; unless protective devices open the motor circuit both booster and motor are likely to burn out. Assuming that the motor circuit is opened, the booster will stop suddenly, reverse its rotation and run as a motor connected across the 115-v. line. As the booster is wound for a low voltage its insulation is likely to break down, otherwise it must run at much more than normal speed. If the booster is wound for a comparatively high voltage and has its fields fully excited, it is barely possible that the set may withstand the excessive speed without injury; but in all probability one or both of the armatures will burst and cause a general wreck. If a short circuit occurs with the booster acting as a motor, it immediately starts to speed up, throwing a heavy over-load on the generator end; if the generator circuit opens it is a case of a low voltage motor connected across a high voltage line exactly as in the previous case.

Failure of voltage in the supply line may have much the same result as a short circuit on the battery line. If the line provides no circuit through which the battery can discharge, the armatures of motor and booster are in series across the battery and the set will continue to run on the battery current with no very great change in speed or excessive amount of current. If the line affords a path for a heavy discharge, either through other apparatus or a short circuit at some distant point, practically the full battery voltage will be thrown across the booster armature, causing it to run at excessive speed; the circuit breaker on the motor end will probably open, leaving the set free to accelerate until the bursting point is reached as in the previous paragraph.

An open circuit in the booster field reduces its voltage to zero and allows practically the same current to flow as if the battery were connected directly across the line; if the motor circuit is opened, the set will probably come to a standstill although there is a possibility of its accelerating to a dangerous speed on account of armature reaction or residual magnetism. In any event, the current will probably be large enough to injure the battery and possibly burn out the armature of the booster. If instead of an open field we have a weak field there is a strong tendency to speed up, which will be counteracted by the motor acting as a generator; if the motor circuit opens, the set will speed up until the booster with its weak field generates a back electromotive force nearly equalling the difference in voltage between the battery and the line, which may require a speed greatly above normal, or until the set is wrecked by the excessive speed.

Large units as a rule have a narrower margin of safety in respect to abnormal speeds than small, the effects of a wreck are, of course, much more serious; they are therefore frequently equipped with a centrifugal device with electrical connections for tripping the circuit breaker at a speed slightly above normal in addition to or as a substitute for the purely electrical devices previously enumerated.

The motor generator set may be preferable to the booster in some instances on account of its greater range of voltage; it can deliver current at practically any voltage between zero and the maximum for which it is designed. A booster set designed to reduce the line voltage to zero, or to a low voltage would, in most cases, be larger than a motor generator designed for the maximum voltage required. There are, however, comparatively few cases where the wide range of voltage is of practical importance; for experimental work, including other uses besides battery charging, the wide range may be imperative or of sufficient advantage to give the motor generator the preference.

In some cases, it may be desirable to provide one set for charging two or more batteries differing in number of cells and perhaps in the number of amperes required for charging; in which case a simple calculation along the lines of those given above will show whether the generator or booster is preferable. Usually the charging is confined to batteries of a constant number of cells with an occasional call to charge a single cell or a battery of from 3 to 6 cells; a motor generator is not required for such work, as it is a simple matter to arrange a switch so as to connect the charging circuit directly across the booster terminals in which case it becomes a low voltage generator eminently suited for the work.

The fact that with the motor-generator set there is no electrical connection between the charging circuit and battery circuit should not be overlooked in making a choice between it and the booster set; this is a distinct advantage in favor of the former although, as a rule, not of sufficient importance to justify any great sacrifice in respect to first cost and economy of operation. The charging circuit is rather liable to grounds on

account of acid fumes, and in some cases, the use and abuse of portable conductors; in most cases, the power circuit is more or less grounded. The result of the combination is that the operator is more frequently annoyed by shocks while handling apparatus and that there is a somewhat greater liability of short circuits than would be the case with the isolated circuit of the motor-generator. This disadvantage may be considerably reduced, though not entirely overcome, by care in installation.

Electrical Equipment at Coal Mines

By Jack L. Ball

IT IS not generally known that next to central stations the stationary power plants at coal mines consume more steam coal than any other single industry in the United States. Based upon careful estimates, it is found that the annual coal consumption at these mine plants is 22,000,000 T. A conservative estimate of the industry as a whole shows that there are 2,000,000 installed boiler horsepower.

Careful investigation and numerous reports show that the fuel consumption per boiler horsepower-hour is higher than in any other major industry. This shows in part why purchased electrical energy is rapidly supplementing steam as motive power in this basic industry.

240 KW. MOTOR GENERATOR SET SUPPLYING CURRENT TO COAL MINE

Further, the large percentage of new mines are being entirely electrically equipped, using purchased power, the governing factor that has brought about this somewhat radical departure being economy.

Motor-generator sets and rotary converters meet with about equal favor and either gives very satisfactory service. One of the main points that make this type of equipment desirable is that the voltage is steady with variable load, unless, of course, the machine is subjected to excessive overload, which occurrence is rare, inasmuch as all circuits are protected with circuit breakers. A mine load fluctuates considerably and can be likened to that of street railway service. With a steam driven unit, unless the prime mover is sufficiently large to care for sudden heavy loads on the generator—oftentimes an overload—the voltage is much reduced with a corresponding loss of power in and about the mine.

To explain the preceding statement, it can be stated that many coal mine plants are still using the original prime mover. As the mine expanded, which called for additional electrical power, often the original generator was replaced with one of larger capacity but driven with the same engine.

Electrical equipment has proven economical at mines when compared with steam inasmuch as depreciation and upkeep is less; labor costs are reduced; boiler fuel is eliminated; less floor space is required; electrical machinery is, in itself, economical, and further, electrical equipment has been so simplified that it does not, of necessity, require skilled operators.

One large coal company has two mines near each other. One of the mines has the usual steam equipment, the other electric. Quite a little trouble was experienced at the electrically equipped mine on account of stoppage of power, caused mostly by transmission line breakage in stormy weather. Interruption of power was inconvenient and costly on account of the accumulation of gas and water in the mine. As there was no other source of power available, the management was unable to operate the electrically driven pumps, the motor driven ventilating fan or the motor driven hoist at this shaft mine.

The steam driven 150-kw. direct current generator had become too small for the mine load at the steam equipped mine, so a 250-v., 240-kw. direct current, 350-hp., 4000-v. synchronous motor set was installed. This motor-generator set is now used exclusively for furnishing electrical energy for this mine.

The primary source of power for this set is the Windsor Power Co., Windsor, W. Va. The primary voltage of 66,000 is reduced to 4000 v. at a small substation at the electrically equipped mine and is transmitted from there to the set. The switchboard which is of standard design is placed in the machine room. The main direct current circuit to the mine is protected by three circuit breakers which are set to break the circuit at 700, 750 and 775 amp. respectively. The two automatic breakers are set to open the circuit at 700 and 750 amp., one being placed on the positive and the other being placed on the negative side of the circuit to and about the mine. The installation of these breakers was somewhat in the form of an experiment, but they have functioned perfectly under all conditions to which they have been subjected. The circuit from the old 150-kw. generator was formerly protected by a single-pole breaker that had to be reset by the hoisting engineer dozens of times each day. This seriously interfered with the hoisting operations and the loss of tonnage from this item was considerable.

Should the current be shut off from these mines for any reason, the 150-kw. steam driven generator is put on the line, the generator of the motor-generator set is used as a motor and the synchronous motor is used as a 4000-v. alternator which supplies current for the variable speed induction hoist motor, an induction motor that is used to drive a ventilating fan, and also current for one of two rotary converters which furnishes direct current for motors used inside the electrically equipped mine. The engine driven unit is of ample size to furnish emergency service for both mines and this arrangement has proven quite satisfactory on several occasions.

Carelessness and failure are twins.—Forbes Magazine.

The Use of Exploring Coils for Locating Trouble

A Discussion of Various Types of Exploring Coils and Suggestions for Future Development

EVER SINCE electrical conductors were first installed in ducts or in other more or less inaccessible places, the electrical maintenance man has been confronted with the problem of locating accurately the points of failure of such conductors which arise from time to time. The occurrence of a short, or a ground, or an "open" required that the exact point of trouble be located before steps could be taken to effect a repair. In submarine cable work, especially, the problem of locating a fault is of particular importance, and in that field it is probable that the art has been developed to its highest degree. Indeed, to the uninitiated, the steaming out of a ship to the exact spot of a break in a cable stretching under some 3000 mi. of ocean is a feat which is nothing short of miraculous. Yet this is a common occurrence.

The methods employed in submarine work are mostly resistance methods based upon the Wheatstone bridge principle with which every electrical man is familiar. The Murray and Varley loop tests used in this work are generously treated in various handbooks and in this article it will not be necessary, therefore, to go into the details of these well known tests.

While the resistance measurement methods of locating faults can be applied successfully to comparatively high resistance circuits, such as telephone and telegraph circuits, difficulties are encountered when these methods are applied to heavy power lines. If a ground or a short occurs on a power cable, it is difficult to localize the fault electrically because of the low linear resistance of the conductor. While in the case of a telephone line the measurement of its resistance to within an accuracy of one ohm may locate the fault within a few feet, in

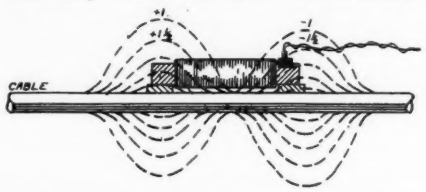


FIG. 1. EXPLORING COIL FOR USE WITH THREE CONDUCTOR POWER CABLES

the case of a heavy power line the same measurement would not locate the point of failure within a mile or even two miles.

The Compass Method

To overcome the difficulties introduced by low linear resistance conductors, various exploring methods were developed. Of these, the simplest, perhaps, is the compass method in which a direct current is sent through the cable and by means of a commutator its direction of flow is reversed, say, every 10 or 15 sec. While this periodically reversed current is being impressed on the line, a lineman explores the cable with a small pocket compass. As each reversal of the current in the cable causes the compass needle to reverse, it is evident that the location of the fault will be indicated when a point is reached where the action on the needle ceases.

The compass method, although satisfactory in certain cases, is not applicable to ordinary cable installations, where a number of power cables are in close proximity to the cable to be tested. The method also requires a fairly strong current in order to give indications over long lines. Its use is limited, therefore, to comparatively simple installations of no great length.

The Simple Exploring Coil

The introduction of the exploring coil in connection with a telephone receiver designed to respond to

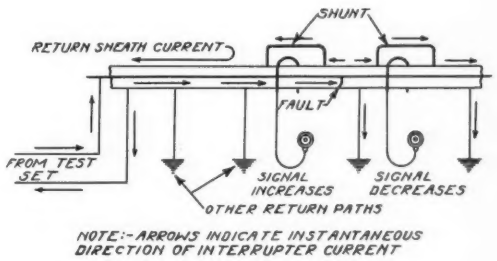


FIG. 2. SHOWING APPLICATION OF SHUNT IN CONNECTION WITH EXPLORING COIL

magnetic fields created about cables by alternating or pulsating currents was a great improvement over the compass method. It was far more sensitive and the coil was not so easily affected by strong magnetic fields from adjacent conductors. Exploring coils have been used by "trouble shooters" on telephone lines for years and also to some extent in power work. On overhead lines the exploring coil is often attached to the end of a long bamboo pole so that the lineman may explore the lines without the necessity of riding the cable. In this work the exploring coil is in many cases simply a coil of magnet wire wound on an iron core.

When it became necessary to locate trouble in power cables encased in continuous lead sheaths, the simple exploring coil proved unsuccessful. In cables of this type, due to the low resistance of the leaden sheath, a large portion of the identification current (especially in the case of a ground) returns through the sheath, thus neutralizing the magnetic effect of the current in the cable.

Exploring Coil for Three Conductor Cables

To overcome the difficulties introduced by the lead sheath, a new type of coil was devised in which the winding was laid transverse to the cable and the core parallel to the cable. This coil and its principles of operation were described by Wm. A. Durgin, in the Electrical World of Nov. 25, 1909. It depends for its application upon the fact that the conductors in most three-wire cables are in practice laid up helically with a lay of about 20 in. The coil is applied to the cable as shown in Fig. 1. The signalling current used in the cable is interrupted by a motor driven carbon breaker and ordinarily has a value of about 20 to 30 amp. at

110 v. When testing for the location of a fault in a three-conductor lead covered cable, a number of different signalling circuits are available; in the case of a short, however, it is usual to use one pair of the three conductors as the conducting loop through which the signalling current is sent from the station.

The foregoing method is ingenious and gives good results but has the disadvantage of requiring rather heavy signalling currents.

Another interesting type of exploring coil is the Matthews "telefault." The coil used with this set is composed of two laminated steel cores separated from each other by a fiber block, each core being wound with three distinct windings. The windings are so arranged as to form an arc of a circle, which make it convenient to apply the coil to round cables.

The Use of Shunts with Exploring Coils

To overcome the annoyance caused by the return current on the sheath when testing on single conductor cables, the exploring coil has been recently supplemented by a shunt. The application of the shunt and exploring coil is shown in Fig. 2. The shunt consists

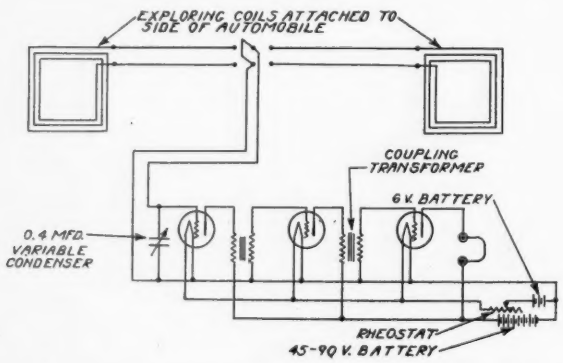


FIG. 3. WIRING DIAGRAM OF EXPLORING COIL CIRCUIT USING VACUUM TUBE AMPLIFIER

of a piece of 4/0 copper bent U shape, 10 in. long by 4½ in. high. When using it, good contact must be made. If the coil and shunt is applied before the fault is reached, the removal of the shunt weakens the signal, but when placed beyond the fault the removal of the shunt will increase the signal current in the receiver.

Recent Developments

All of the above methods require that the exploring coil be applied close to the cable. This, especially with underground work, is a disadvantage, as it requires the testing to be done only in manholes or other points where convenient access to the cable may be had. The desirability of devising some other method which will avoid the necessity of climbing down manholes and for speeding up the work of locating trouble has led several electric companies to investigate the possibilities of the vacuum tube amplifier in this direction.

Exploring coils might be conveniently carried on the sides of automobiles, and if provided with amplifiers the minute currents induced in these exploring coils by signal currents in the underground cable could be amplified sufficiently to be heard in telephone receivers. For the purpose of eliminating interference due to other cables the amplifying circuit can be tuned to respond only to the particular frequency of the signal current by means of variable condensers.

By arranging two comparatively large exploring coils on each side of the automobile, and connecting them to a vacuum tube amplifier circuit such as shown in Fig. 3, it might be possible to follow the cable route to the exact point of trouble without delay. The circuit shown in Fig. 3 is similar to that used in connection with the apparatus used for guiding ships through channels by means of a "leader" cable laid under the water. In the latter field this method of detecting alternating currents has proved very successful, even when the "leader" cable was laid at a depth of 30 fathoms (180 ft.).

In this suggested method of locating faults in underground or overhead cables, the vacuum tube amplifier holds great possibilities and electric companies will without doubt find it well worth their while to do some experimenting along these lines. The vacuum tube amplifier need not be described in detail here. It is the familiar arrangement now so popular in radio work. Three stages of amplification as shown in Fig. 3 will probably be sufficient. A 6-v. storage battery is used for heating the filaments and a 45 to 90-v. battery is used in the plate circuit. For tuning, a variable condenser of about 0.4 mfd. will probably give satisfactory results.

The matter of fault finding is of considerable importance to operating companies and the vacuum tube opens up a new field for development in this direction.

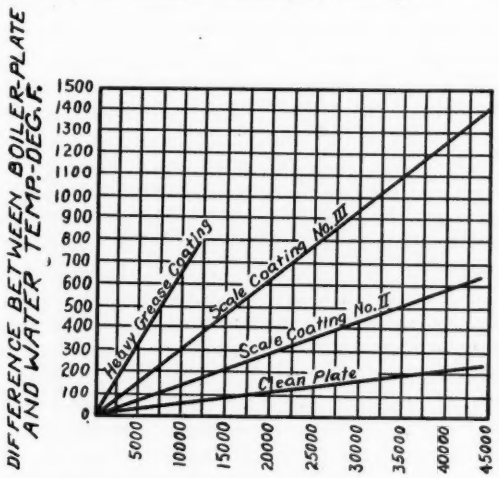
Boiler Scale and Its Removal

Among the first difficulties met in the operation of steam boilers was the formation of scale on the water side of the heating surfaces, and this characteristic of boiler operation still exists and is one of the factors that has governed the design of boilers. Water in its natural state almost invariably contains scale forming material in solution which, under the concentrating effect carried on in the boiler, precipitates out of the water and becomes attached to the interior surfaces of the boiler. Here the scale remains, quite effectively preventing the transmission of heat from the hot gases to the water, a coating 1/16 in. thick cutting down the efficiency of the boiler 12 to 13 per cent.

The amount of scale which will accumulate over a given period of time depends upon the amount and character of impurities in the water as fed to the boiler, the amount of water evaporated during the period, the rapidity of water circulation in the boiler and the frequency with which the blowoff valve is opened.

Carbonates, which constitute the principal temporary hardness in waters, are precipitated out when the temperature reaches around 210 deg., forming a soft scale. The sulphates, however, are not precipitated by temperature until it reaches about 300 deg. and the scale formed is dense and hard, therefore more troublesome than the carbonate scale. Where the water circulates rapidly, it carries the precipitate with it, preventing, to a considerable extent, the settling out of the scale forming material thus keeping it in circulation until the concentration is reduced by blowing off a portion of the boiler contents.

In spite of all efforts to prevent the formation of scale in boilers by treating the water chemically both before it enters the boiler and in the boiler itself, experience has taught that often chemicals cannot be depended upon absolutely to keep a boiler entirely free from scale. Many treated waters still contain a percentage of solid matter—seldom less than five grains to the gallon. When the water is turned to steam the solid matter is deposited, chiefly on the tubes and crown sheet. In the case of a 100 hp. boiler about 1,000,000 gal. of water passes through the boiler in a year, and along with it 5,000,000 grains or 130 lb. of solid matter, nearly all left on the tubes in the form of scale. Figuring the waste of fuel to be 2 lb. of coal per day of 10 hr. each for every pound of scale present, 130 lb. of scale means a loss of 260 lb. coal per day or 3¼ T. a month. It will be seen how important it is that every boiler be taken out of service at intervals varying from one to six months in order that it may be cleaned thoroughly and put into best



EFFECT OF SCALE ON HEAT TRANSMISSION

condition to transmit heat from the gases to the water.

In many plants the time of cleaning is established after a study of operating records showing flue gas temperatures and evaporation per pound of coal. With such data on hand over a period of a year or more, calculations can readily be made showing when it will pay in dollars and cents to take the boiler out of service for a thorough cleaning. The effect of scale on heat transmission through boiler surfaces is well shown by the curves reproduced here from Helios. Scale coatings No. II and III are of the same thickness, 0.217 in., but of different heat conductivity. From this it is evident that from the time a boiler is put into operation after a thorough cleaning, the flue gas temperature will gradually rise as scale accumulates giving a positive indication of the general scale condition of the boiler.

Although the boiler may not have enough scale over its entire surface to interfere materially with heat transmission, there may be pockets or spots where scale has collected to such an extent as to cause overheating of the metal and bagging, burned tube ends and expansion strains which are likely to result in boiler accidents. For this reason, boilers should be regularly taken out of service and given a thorough mechanical cleaning to remove scale from the heating surface.

Without thermometers giving flue gas temperatures, the accumulation of scale will not be apparent except perhaps when an attempt is made to force the boiler considerably above its rated capacity. It is not uncommon to take from 250 to 450 lb. of scale from a single boiler which was thought to be in fair condition, and a case is on record where as much as 1000 lb. were removed from a boiler pronounced by an inspector as "comparatively clean."

Mechanical devices in common use for cleaning the water surfaces of boiler tubes are of two general types: one employs the vibration principle and the other grinds the scale off by means of revolving cutters. Either type may be used in curved or straight tubes of water-tube boilers, but the vibrating type may also be used to remove the scale from the outside of fire tubes.

These devices are run by compressed air, steam or water, and for water tubes some designs fit the inside of the tube closely so that they will not pass over scale, thus insuring a perfectly clean surface. Cleaners employing the vibration principle deliver to the metal of the tube light hammer-like taps in rapid succession which set up a vibration in the metal of the tube, thus jarring the scale loose, permitting it to fall and be blown out by the compressed air used for driving the cleaner.

In the other type of cleaner, revolving cutters, resembling spurs, are assembled on hinged arms and swing out against the interior surface of the tube when the shaft is revolved at rapid speed by the motor. Scale is thus chipped off the metal of the tube.

Scale which has become attached to flat surfaces, the boiler shell, in corners and pockets, is usually scraped off or knocked off with a hammer and cold chisel.

Transfer of heat from the furnace and gases to the water in the boiler with as little loss as possible is one of the big problems in boiler operation. Scale accumulation can readily cut the efficiency down 10 to 15 per cent without being noticeable to the fireman who is not equipped with flue gas thermometers and does not keep an accurate record of evaporation. "Out of sight, out of mind," describes quite aptly the attitude of many managers of power plants in regard to boiler scale and for such the best object lesson is an exhibit of two or three wheelbarrow loads of scale taken from his boiler.

U. S. Civil Service Commission announces examinations June 7 and July 19, for Laboratory Assistant, Junior Grade, $1000 a year, and Senior Aid, $900 a year, to fill vacancies in the Bureau of Standards, Department of Commerce, for duty in Washington, D. C., or elsewhere, and in positions requiring similar qualifications. The registers of eligibles resulting from these examinations will supersede those resulting from the unassembled examinations for these positions, receipt of application for which closed on March 23, 1922. Appointees whose services are satisfactory may be allowed the increase granted by Congress of $20 a month. Competitors will be rated on physics and chemistry, mathematics (through trigonometry), mechanical drawing (to be handed to the examiner on the day of the examination), education and experience. Applicants must not have reached their thirty-fifth birthday on the date of the examination.

Trouble Hunting---XVIII

By John Pierce

THE BOILERS set up, we went back, with a part of the men, and started work once more on the hoist. Other men were put to fitting the new steam line, and yet others to piping and connecting the auxiliaries of the new plant. In my oil line suction we ran a 1½-in. pipe so that the exhaust from the pump would heat this line as the oil was heated at the old boilers. I had ordered and received a pair of Marsh steam pumps for my fuel system, and these were set up on bases of concrete, having every part so that the fuel could be pumped by either pump, passing through a set of strainers, which was also in duplicate, so that either one could be cleaned at any time without stopping the pumps. There was fitted, also, a relief valve between the discharge and the suction so that excess oil would flow back to the suction line. This relief valve was cut in ahead of the strainers so that excess oil would not tend to clog them that much sooner. On this new work I used all new valves, though I had not a single new fitting.

I then dug out an old closed feed-water heater and having no base for it, stood it on end, built a neat round form and poured cement. This came up some 4 in. along the body of the heater and gave it plenty of support so that it would not fall over. I left the form large enough so that there was a shelf 18 in. wide all around the heater, which made an excellent place for oil cans and tools. I ran my lines into the bottom, or near the bottom, and the discharge from the top. About halfway up, I tapped a ⅜-in. hole and put a pair of governors on my oil pumps. This would not work at all, as the oil was entirely too sluggish to actuate the governor, so then I tapped for and connected a 1-in. line and bushed down to the smaller size right at the cylinder of the governor, and found that she worked all right. We also ran a bypass around the heater so that we could pump direct to the burners, and not shut down if we ever wanted to work on the heater for any purpose.

I went down into an old mine and located two pumps exactly alike which I took apart and rebuilt. These pumps were put together in the best way possible. They were not exactly alike in every respect, but were of the same size. Therefore I found, after making them as good as new, that I had a dandy set of feed pumps. The exhaust from these pumps went into the fuel oil heater between the fuel oil pumps and the boiler. At the point of leaving the heater, I connected a pipe, which ran several hundred feet and emptied into a sump. This sump was a stone tank, cement lined, which I had built to catch the water which passed through the jackets of the compressors. By the time the feed pump exhaust reached there, it was practically all condensed. I also used this sump as a discharge from the pump which I had located down the main shaft, and of which I have previously written. We had to have a pump to take care of the water and condensate which came to the tank, and put it back in the main reservoir above the plant. So we had to go to the "rebels' heap" once more. We found the parts of a pump there and made the rest. All we had to make were the pistons, rings, plungers, rods and rocker arms. But we made a good pump out of it and set her up ready to work.

The next thing that came up was orders from New York to rebuild the old condenser which was lying there and put that to work. This old girl had been in service once before at this plant and was a failure on account of the tubes stopping up in a few days with the sediment and precipitate from the mine water. But the fellows in New York imagined they knew all about it, and said put her back in commission. She had 1150 tubes in her, ½ in. diam. by 10 ft. long. Of this entire number seven were *not* full of mud, dirt and a sort of scale. I had an air motor, and rigged up a hollow drill and we got busy on those tubes. We got every one cleaned out, and found about 15 or 20 that had to be replaced. As we had no extra tubes, we simply fixed them by driving wooden plugs in them.

The pump connected with the condenser was in a deplorable condition, but by now we were accustomed to finding things in deplorable condition and so were not surprised. Every spider, stud, valve, spring, piston, plunger and rod had to be taken out and replaced with a new one. The cylinders, for a wonder, were in good condition. I cannot understand this at all—why the rest of the entire pump should be completely eaten away—even to the brasses—and the cylinders not. However, this was something which we were thankful for and we did not object. The spiders were all replaced from the warehouse, with the exception of one—that one we were compelled to make. We were very fortunate in making such things to have plenty of brass. The old main bearing blocks from the hoist were very heavy, and as there had, in former times, been many of them used and thrown away we had an excellent lot of brass to work on, as they were all of that metal. I would have tried to use them on the engine, but there were more than the engine would ever need. They had originally been babbited, when sent from the factory, but the master mechanic of former years would not rebabbit them and used new ones. It may have been that he had no time to do so, as this engine had, in the past, run day and night.

We had now a pump capable of consuming 40 hp. of steam, the condenser pump proper using another 40 hp., the feed pumps, fuel pumps, two pumps down two different shafts, the sump pump to handle the water from the compressor jackets, the saw mill, the machine shop, a Westinghouse 100-hp. engine, the pump for handling water to be treated—the steam-driven compressor, the Westinghouse to drive a 100-kw. generator; and contemplated putting on the 500-hp. hoist,—all on these two new boilers. And they asked me to pull it all on one if I could. Replying that it was beyond all reason to contemplate the handling of them on the two boilers, let alone one, I was furnished with enough data to keep me reading for two months.

First the theoretical part of it was used. The boilers were guaranteed, so they claimed, to evaporate a certain amount of water per hour. The horsepower was based on 34.5 lb. per boiler horsepower per hour, which multi-

plied by 250 gave each boiler an evaporation capacity of nearly 15,000 lb. of water per hour. And as an engine used only 20 lb. per hour per horsepower, there was no reason why we could not handle three times 250 hp. by equipping either, or both, of them with oil burners and *forcing* them a little. This was their argument.

It was impossible to explain to them the difference between a *boiler* horsepower and an engine horsepower. A "horsepower" was a "horsepower" and there were no two ways about it. The engines should use, not to exceed, 20 lb. non-condensing and the steam driven compressor was *guaranteed* to take only 17 lb. flat per horsepower-hour non-condensing and 13 lb. when hooked onto the condenser. Careful explaining did no good.

One of the superintendents seemed to see into it; at any rate, he said he was confident I knew what I was talking about, and if I said it couldn't be done he'd bank that it couldn't.

Just because the *books* sent out by the people selling the boilers said they'd evaporate a certain amount of water, why naturally there was nothing else to be considered. So we fired up. The fire box, as I have said, was only 6 ft. long and would have been ideal for coal burning. Of course the front water leg was on an outward angle, and the drum was overhead, several feet up in the air. The water glasses were just over one's back, and as the fittings were, though new, all inclined to leak badly, it would have been a great pleasure to be a fireman and to fire with coal having a constant stream of hot water coming down on one's neck and back.

The fire boxes being so short, I made a Dutch oven as wide as the door, right at the door, 22 in. long, and only 8 in. inside at the outer end. I made a steel casing and mounted them on neat legs made of pipe, and lined them with fire brick. I had a peep hole over the burner and made the casing so that the burner could be uncoupled at the union, a little slide door raised up, the burner taken out, and a new one installed in less than five minutes. On the top we placed a sliding door so we could start our fire, regulate the air at the burner or look into the furnace just as we wished. Each of the four fire doors to each boiler had one of these. The steel casing around the boiler, and supporting it, had a 9-in. brick lining. The flame from the burners beat directly back against these brick and as soon as the heat was transmitted to the casing it began to buckle. We had arranged the furnace with the grates in them, leaving air spaces between the bricks which covered them. The "ovens" we made gave us a fine looking job, and we were pleased with the outward appearance.

So, as I said, we fired up. I was surprised to see the grates begin, in less than two hours, to melt and bend, dropping down and letting more of them go the same way. I discovered that with the short fire box the flame was curling downward, as well as upward, after striking the wall, and thus the grates were burning. Also the cast-iron door plates and frames were warping. We shut her down and moved our burners in 6 in., cutting new nipples to do so. Then we tried it again, but found they were still too far out. So we moved them in some more, and later had to move them in flush with the door proper. As before stated, we could not remove any of the front of the boiler because it supported the boiler proper.

We fired up again the next day and tried her out again. In about 4 hr., watching her like a hawk every minute, we noticed her casing start to bulge and she showed signs of coming down, so we cut out the fires. We had, in the morning, rearranged the grates and the furnaces. We then took everything out of the furnaces and put in another foot of fire brick, starting at the bottom of the ash pit and building to the flues. The floor of the ash pit was covered with 6 in. of sand and laid with fire bricks. Then we started again with less of fire space than we had before. It did very nicely so far as protection went, but we could get, to do our best, without making lots of smoke, only about 250 hp. This was not satisfactory at all, for we had to have more, and I was convinced that we could get more than that. I really figured that with new boilers, perfectly clean, we should get from 325 to 350 hp. from her, and she was using too much oil to make us satisfied along those lines. I suggested cutting in the two boilers and shutting part of the work down every so often while we cleaned them, but this suggestion was killed in a hurry. One boiler at a time, and nothing else, was to be used—this on the wire from New York. We then got a message from New York to tear away the dutch ovens and prepare to rebuild the furnaces and fire the boilers as per instructions coming by mail from New York, and furnished by oil-selling people there, "who ought to know how to fix them."

We got all ready and waited. In the course of 10 days we had the plans. Looking them over, I showed my people that these plans were practically the same arrangements as we had made when first starting up. They insisted that we leave only the original 9 in. of brick lining along the wall, and were positive the upflow of oil would pull the flame up and take care of the boiler walls and grates. I asked them to let me go and get someone else to do the work, as I knew what would happen. They wired me to stay, do as they specified (the New York office) and they would accept all responsibility for the results. I told them I knew how to burn oil, to handle boilers and to arrange furnaces, and I knew this scheme would not work. I told them also that I could refer them to the editor of the best power plant paper going as to whether or not I did know, and gave them the address of Arthur L. Rice, editor of Power Plant Engineering. They said they were perfectly satisfied with me and my knowledge, only they wanted it done their way.

Before doing it, I told them there was one other way in which I could generate 300 hp. of steam from the boilers, using two burners, and using less oil, and not damage the boilers; and if I was allowed to do this I'd afterwards do it their way and show them I was right. They agreed to this, and said go ahead. The superintendents by now were both sick of the boilers, for every time one was "blown down" the doors had to be opened and the plugs all tightened, as they would invariably go to leaking. The money was running short by this time, also the force of men had been cut to nothing, and affairs looked bad. I cut two 2-in. holes in one end of one of the boiler casings, removed one brick, 6 by 6 in., at each hole and fitted a Tate Jones burner in each place. I cut seven pieces of 12-in. pipe 20 in. long and laid them in a row from front to back across the fire box of the boiler. These were left 30 in. from the end wall of the boiler, and between the ash pit doors. This left

room to open any or all the doors. Across these, lengthwise, I laid a steel plate. At the other end of the ashpit, from front to back, I laid up a brick foundation with a plate resting on that. Then I cut flues—old fellows which were no good any more—and laid them on the plates, running from one end of the boiler to the far end of the 12-in. pipes at the other end. On top of these flues, and they were laid one directly against the other, I put sheet iron. On the sheet iron was placed a couple of inches of sand. My idea was to make an airtight floor for my fire box, the air entering the ash pit doors, traveling along under the floor, through the 12-in. pipes and up to the flame. Going under the floor would tend to keep the floor from burning and heat the air. On top of the sand were placed two layers of fire brick, laid well. The walls were given another foot of lining with fire brick, as was the end away from the burners.

When everything was all ready, we fired her up and tried her out. The results were that with the two burners idling along and not forcing them more than what would normally be their work under any ordinary boiler, they supplied us with about 360 hp. of steam. When we tried to force them, however, and to get more steam than this, they would prime. We ran this boiler for a week and used much less oil than the other way of firing, and the superintendents were quite content and so wired New York. But New York said, "Do it as per orders."

I fixed them then, "per orders," and handed in my resignation. They sent over the master mechanic from one of our other properties and he refused to fire them. Then I was requested to reconsider and withdraw the resignation and try them out, *because* if they failed we were done, and they would be compelled to shut down the works. I let the resignation stand, however, as I had good letters from them, and I was sure I'd ruin my reputation if I tried to use those boilers according to their plans. One of the superintendents said he'd try it, for if we did ruin the casing, as I predicted, we'd be down anyway and out of work, and if we did not and they would stand up under it the directors would vote enough more money to go ahead for a time and he needed the job. So he tried it, firing both boilers, and tried to run everything. In 4 hr. they began to buckle and went down, breaking off the headers and scalding a couple of men pretty badly.

It was fortunate that the men were all afraid to go near the boiler room, and only the firemen and himself were present to get burned. Now the place is lying there, dead and deserted by all save the watchman, and over 700,000 pesos lost simply because the New York office would not be persuaded. The next time Uncle John writes his boys, he'll tell about a "gringo" in Mexico looking for a job.

MANY USES have been found for raw or dehydrated coal tar, states W. W. Odell, fuel engineer of the United States Bureau of Mines, in Technical Paper 268, just issued. In fact, these are so numerous that there is no longer an excuse for throwing tar away or disposing of it wastefully. Some of the uses for tar and preparations in which it is employed are as follows: Timber preserving, fuel, tarred felt, paint for stone, brickwork and iron, road-construction material and road-dust settler, waterproofing compounds for cement and for roof paint, germicides and miscellaneous special preparations.

A New Principle of Design for Meters

By J. H. BLAKEY

ABOUT a year ago, MM. Bertillion and Dugit presented to the French Academy of Sciences a communication upon the possibility of using the Archimedean spiral in the design of the dials of industrial meters. Since that time the idea has been tried out with very satisfactory results, the new meters having a constant sensitiveness, especially at the extremities of the scale, which is rarely found in the meters in general use, according to M. Aug. Dumont, who writes on this subject in Le Genie Civil of Jan. 7. If we consider a curve S (Fig. 1) capable of turning around its pole, O,

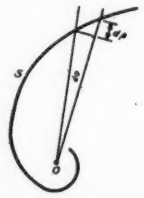


FIG. 1. PRINCIPLE OF ARCHIMEDEAN SPIRAL

and if it is required that a variation, dp, of the length of the radius vector correspond to an angular displacement do, such that the relation of these quantities may be constant, we shall have $dp \div do = k$. The law of correspondence is $p = ko + a$ constant.

If then an Archimedean spiral is turned around its pole, it will cut a radius vector in points equidistant for equal angular displacements. Reciprocally, in making a straight line turn around a center (this center being the pole of the curve) it will cut an Archimedean spiral in the same plane at equidistant points for equiangular displacements.

An application of this principle has been made to a protractor. The ordinary protractor of reasonable size

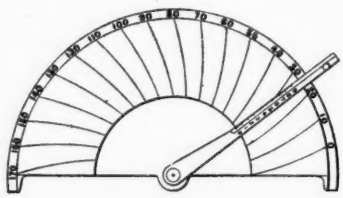


FIG. 2. PROTRACTOR WITH SPIRAL SUBDIVISION SCALE

does not allow a determination of less than a quarter of a degree, unless used with a vernier. The spiraloid protractor shown in Fig. 2, with a diameter of 25 centimeters, shows amounts as small as one twelfth of a degree, or 5 min., and that without a vernier. To get the same precision with an ordinary protractor, at the periphery of which a half millimeter would correspond to 5 min., it would be necessary to have a circle of 70 centimeters in diameter.

BY A VOTE of 65 to 26 the voters of the little city of Simla, in the Pikes Peak region, agreed to a $10,000 bond issue, the money secured to be used to erect a municipal electric light plant.

First Steps in Emergencies---I

What Should Be Done in Case a Baffle or Arch Falls

IN CASE of an accident to a boiler, or any other piece of apparatus for that matter, the first thought that pops into a man's head, whether it be conscious or subconscious, is that of seeking personal safety. It is as automatic and as natural as the thought of getting something to eat when you are hungry and is no more to be condemned or lamented. This thought, however, is liable, if not likely, to result in more harm than good being done, unless it is immediately supplemented with some constructive reasoning.

To keep your head on your shoulders would be the obvious advice. Keep cool, not so cool that you become frozen to the spot, but cool enough so that it is possible to think without panic. You will find the older engineers of the plant, who have experienced accidents before, right there on the job in case anything goes wrong. Only the inexperienced man finds himself entirely at sea at such a time.

During an emergency there is not always time available to think things out to a logical conclusion. A man is forced to think quickly and make snap decisions, which are just as apt to be wrong as right unless steps have been taken to insure a correct solution.

Such insurance may, in a degree, be obtained by knowing, absolutely, the function and method of operation of every piece of apparatus in the plant; knowing every valve and every length of pipe, what it contains and what it connects. Become familiar with the layout of your plant; note the location of every valve so that you would be able to find your way about in the dark if necessary.

To test yourself in this respect, make a sketch of your boiler room showing the plan location of all boilers, pumps, fans, stoker motors and valves. If you are not able to make such a drawing from memory, make one from actual observation, study it and then see if you can copy it from memory. You will probably find that you will be unsuccessful at first, but try again until you can. You do not have to be an expert draftsman to make such a sketch; any schematic layout that will convey to your own mind the desired information will suffice.

Another bit of thinking beforehand that will prove to be of value in case of emergency is to imagine a mishap on some given piece of apparatus and then determine what you would do and in what order. Think what you would do if this or that thing happened in the boiler, say.

Suppose that on opening the inspection door of the furnace you discover bricks on the grate, the first thing that should be determined is where they come from and then what harm will result. They may come from either the wall, baffle or arch. An inspection of the brick may show, by its shape, where it came from; but in any event it is well to examine the walls and arch, and, if possible, the baffle to find a place where there are bricks or tile missing. Has any damage been done to the grate or is there likely to be any, and if so what will be its extent? If a stoker is used, will it be able to dispose of the foreign material along with the ash and clinker without injury to itself or will it break the clinker grinder or damage the water back?

Suppose that a portion of the baffle between the first and second passes is down. What then? The only result will be that a portion of the gases, large or small, depending on the size of the breech, will be short-circuited, more or less directly, to the third pass. This means, of course, that only a relatively small portion of the heat will be abstracted from the gases and they will enter the uptake at a high temperature. The ultimate result will be a decided loss in both capacity and efficiency of the boiler. Such an accident is more than likely to occur during a period of peak load, in which case it may make it impossible to carry over. The only thing that can be done is to carry on as well as conditions will permit until such time as the defective boiler may conveniently be taken off the line for repairs.

Dislodged wall bricks will not prove serious, excepting insofar as this condition allows the common brick backing to be directly subjected to the heat of the furnace. This brick will fail rapidly, thus adding to the cost of repairs.

The falling of a combustion arch is serious in proportion to the amount that falls. If the whole arch gives way, there will be but an ineffective reflecting surface remaining with which it may be impossible to ignite the green coal as it is fed onto the grate, in which case it will be necessary to shut down that unit. In any event the superstructure or roof of common brick will be subjected to the intense heat of the furnace and will be burned out. With a flat suspended type of arch, the whole arch is not likely to fall at one time and therefore the consequences are not likely to be as serious.

Any such defect that develops should, of course, not be permitted to run any longer than is absolutely necessary. Any delay in making repairs simply means that they will be more expensive when they are made and should not therefore be tolerated.

The failures cited are rather more in the nature of emergencies than accidents, although the element of chance is always present. Such mishaps are always to be expected and should be thought of, if such a thought is congruous, as routine contingencies of the boiler room.

There are, however, other situations that may arise that would require quicker and more detailed thinking, for which it is wise to be, in a measure, prepared. It is, of course, impossible to foretell with any degree of certainty under just what circumstances any particular mishap will occur, but it is well to work the imagination and to give the possibilities some thought so as not to be caught without any plans to prevent a spread of destruction.

Mistakes are made on these occasions either because of insufficient knowledge or inaccurate and slow thinking and acting. The precaution to be taken is to inform yourself as to the functions of the apparatus under your charge and then plan ahead what you would do under certain hypothetical conditions. Future articles will deal with conditions that are likely to occur during accidents in power plants.

THE DAMAGED coal mines in Northern France are being repaired at a gratifying rate. They are expected to be in normal working order by 1926.

Handling Water in the Distilled Water Ice Plant

Keeping the Plant Tuned Up; Saving Stray Heat Units. By A. G. Solomon

AT THE BEGINNING of nearly every ice season this expression is often heard: "There is every reason to believe that this ice season will be one of the best that we have had for several years." A good ice season means that the ice plants must produce every block of ice that can be turned out.

Hopes of all the ice plant engineers are high at this time and they plan and figure on what a good run they will make. Most engineers have just cause to look for good results, as the plants have been carefully overhauled and every defect that gave trouble the year before has been corrected.

Warm and cool days are so well mixed at the start of the season that the engineer is able to note little faults in pipe work and other things and remedy them. An engineer is wise if he takes advantage of every short shutdown that occurs during the first part of the season.

The pocket notebook must be kept in his most handy pocket and even the seemingly small weak points must be marked down. When the cool day comes, and the demand for ice falls, the notebook must be carefully looked over and every repair or change made that is possible.

Just as soon as a note is jotted down in the book it is a good idea to make a list of material needed, and then see that the material is on hand when the day of the shutdown comes. All material for a certain job should be labeled and kept separate from other supplies. If this is not done, the material will be used elsewhere or misplaced.

Importance of Small Items

Do not put off anything that will help to insure the plant against a possible shutdown, or even a slowdown during the time when ice is needed. It is well to bear in mind that the breaking or other failure of the different small parts of the ice plant can just as surely shut down the whole plant as can the more serious accidents. Do not allow the neglect of the little things to be the cause of lost capacity.

Worn valve gear on the water and brine circulating pumps will be sure to cause trouble. A centrifugal pump, with the shaft worn where it passes through the stuffing-box, will mean that the packing will have to be renewed often, and this little job of packing requires the stopping of the pump and the interruption of some part of the service.

The valve gear, valve stems and piston rods of the steam pumps and the shafts, bearings and end play of the centrifugal pumps must be examined during the winter, and if any wear is apparent, repairs or replacements must be made.

The brine agitators, and the different parts of the ice handling cranes and hoists must not be neglected. Overhaul all the small and seemingly unimportant parts of the plant just as carefully as the main engines and compressors.

Begin at the very start of the season to follow a regular and systematic course in the cleaning of the different parts of the equipment.

Condensers

First to be considered are the steam condensers. These are always the cause of work and worry as they must be kept clean, yet not be pounded to pieces. There is not more than one ice plant in every 25 that has enough steam condenser surface.

There are some places in the country where the removal of scale from the condenser surface is given little thought, as the scale does not form fast and its nature makes the cleaning easy; but the circulating water used in the greater number of plants contains sediment that causes the accumulation of thick, hard scale that sticks so tight it is almost impossible to remove, and in such plants the cleaning of the steam condensers is a continuous job.

If a plant has a rated capacity of 50 T., it is not reasonable to expect that a steam condenser capacity of 50 T. will be sufficient to meet the demand during a season of continuous operation. Steam condenser capacity is too often rated without taking into consideration the insulating effect of heavy scale and the varying temperature of the circulating water. Enough steam condensers should be provided so that one at a time can be cut out of service and thoroughly cleaned and painted while the other condensers are furnishing the needed amount of distilled water.

The amount of ice pulled cannot be more than the number of cans that can be filled. If a plant is so located that the icing or re-icing of cars is regular, the ice used can be made from raw water. This manner of disposing of raw water ice will greatly help toward getting capacity in such plants as have trouble getting enough distilled water to fill the desired number of cans. When raw water is used to any great extent, it is best to install a separate forecooler so the temperature of the raw water can be lowered before it is allowed to go into the cans.

When an engineer sees that the distilled water proposition is holding down the capacity of the plant, he must provide a way to get more water. Generally the only way is to put up more steam condensers, and if the increase in the ice output will justify the expense that is what should be done. Have a live steam connection into the steam condensers so that when it is needed, more steam can be used during the times that the exhaust is not sufficient.

As a rule, it requires but a very small amount of raw water mixing with the distilled water, to cause white ice. For this reason, it is best to carry some pressure on the steam condensers. If the pressure carried is close to that of the atmosphere, there is danger of the circulating water finding its way into the condenser through small leaks that can hardly be found. Circulate just sufficient water to keep the condensers from blowing hard.

When it is known that there are leaks in the steam condensers, the flow of circulating water should be stopped before an ice machine is shut down. The reason for this is in the fact that with the decrease in the amount of exhaust steam, the pressure on the condenser

may fall below atmospheric and the raw water will be drawn in. It will surprise many to know how much bad ice is made through neglect of watching the amount of pressure carried on the steam condensers. If the ice being pulled shows white or has a heavy core, the cause is often the mixing of raw water with the distilled. Cut down on the amount of circulating water going over the steam condensers until the pressure is from 3 to 5 lb. This pressure will keep raw water from entering through small leaks. To many people, white ice looks just about as good as no ice at all.

If the oil separator on the exhaust line does its duty, the amount of oil that reaches the reboiler will be small. The removal of this oil will not require continuous skimming, with its accompanying waste of water.

Make regular trips to the reboiler and notice the amount of oil that collects. Allow this oil to skim off whenever necessary, but do not allow one bit more water to go with the oil than is needed to carry off the oil. By watching the reboiler closely, and the appearance of the ice made, it will soon be decided just how much steam is needed to remove the gases and air. There is no need to boil the distilled water violently when only a slight quivering of the surface will do the work. Do not waste steam at the reboiler.

After the distilled water leaves the reboiler, the one idea is to lower its temperature as much as possible before it reaches the ice cans. For this reason, the flat coils will receive the engineer's attention next.

The flat coils are where the removal of heat is accomplished by the circulating water, and every heat unit removed means just that much less work for the ammonia compressor.

Do not be satisfied unless the distilled water leaves the flat coils as cool as possible, depending on the temperature and amount of cold water available. The distilled water can be lowered to a temperature that is within 3 deg. of the coldest water in the plant. Do not use water that has already performed work and absorbed heat from the ammonia condensers. Use cold water direct from the wells or other source of supply; and use as much as is necessary unless there is good reason to practice economy at this point.

The distilled water must travel slowly and if its temperature can be further lowered by a still slower speed of flow, the installation of more flat coils should be considered. Two coils operated in series will often give a lower temperature than when the coils are used as a single unit.

Experiment until the lowest practical temperature is found and then do not allow a higher temperature. Remember that every degree that the temperature of the distilled water is reduced before it enters the forecooler means a saving in refrigeration.

Do not increase the fuel bill by the needless steaming out of the flat coils. The frequent and regular steaming of flat coils is a bad habit in many plants. A good rule to follow is to steam out the flat coils when oil begins to show on the water entering the forecooler. If the oil has been properly removed at the exhaust separator and at the reboiler, the amount of oil that gets into the flat coils will never do any harm. Let it stay there as long as it behaves itself and lies still. Don't stir up oil and dirt and waste steam. Every pound of steam used for unnecessary steaming out purposes means just so much more fuel burned to produce a ton of ice.

Cold Water to Ice Cans

Some engineers do not cool the water in the forecooler and give as the reason that it takes the same amount of refrigeration whether the heat is removed in the forecooler or in the ice tank. It may prove interesting to give the forecooler a fair tryout. The transfer of heat from the water to the ammonia in the coils is more effective in the forecooler than in the ice tank. The heat can be taken up with greater economy in the forecooler as the evaporating ammonia is in close contact with the water; and all engineers will acknowledge that a cake of ice can be frozen more quickly when the water enters the can at a temperature of 42 instead of at 75 or 80 deg.

Put the water in the ice cans at as low a temperature as possible, and the plant will either produce more ice at the same cost or the same amount of ice at a lower cost. Cost of production is the one big thing that counts. Cost of fuel per ton of ice made is the real proof of the economical operation of the plant. So that if it costs less to remove heat in the forecooler than in the ice tank, the forecooler is the proper place to give the heat units the hard fight.

After the water has been cooled, do not allow heat to enter it again. The water line from the forecooler to the can filler hose should be insulated. If anyone doubts the need of this insulation, just hold the hand on the can filler after it has been idle for 10 or 15 min. The first can filled after this pause will be filled with water many degrees warmer than the water in the forecooler. Always remember that every unnecessary heat unit allowed to enter the water means a great deal of heat when a whole season's run is considered.

The can fillers must be properly set so that the cakes of ice will weigh what they should. If 300-lb. cakes are made, the filler should be set so that the filled can will contain 308 lb. of water. The 8 lb. overweight is a fair allowance for the melting in the dip tank.

A good way to set a can filler is to place an empty can on a scale and note its weight. Then allow water to flow in until the 308 lb. net is shown. Mark the can on the inside at the height of the water. When it is known just how high the water must be, it is an easy matter to adjust the filler.

Short weight is bad, as it is unfair to the wagon men and to the people who pay for the ice.

Make full weight cakes, but do not make more overweight than is necessary and just.

It is hard to close up the top of a long cake of ice; and if the water in the can is at a higher level than the brine in the ice tank, the top of the cake will have a very bad appearance. Freeze the ice up solid, for there is no true gain or economy in pulling ice that has a wide shallow hollow at the top or a narrow unfrozen hole half through the length of the cake.

A meter to detect earth currents which eat holes in water and gas mains has been developed by the United States Bureau of Standards. The device will save cities millions yearly. It shows where electrolysis is destroying pipe lines. Engineers thus are warned where insulation is needed. Successful experiments have been made in Chicago.

Packing the Water Ends of Pumps

EVERY ENGINEER is familiar with the fact that in packing the water end of a boiler feed pump, due allowance must be given to the swelling of the packing. In packing a pump it is usual to allow ⅛ or ¼ in. space between ends. The packing used for water end plungers is usually known as "Tucks" hydraulic pressed and unless it is soaked before using is capable of exerting a tremendous expanding force.

In a certain boiler feed pump, operating against 115 lb. boiler pressure with water at 203 deg. F., the packing ordinarily lasted about 8 mo. It finally was concluded that the packing gave out too quickly and it was suggested that a new method be tried out. The next time the pump needed repacking, only 1/16 in. space was allowed between the ends. Of course, anybody knows that this is only a means of inviting trouble; but we all do foolish things occasionally, sometimes knowingly. After the pump was started up, it operated without any trouble during the first day, except that it seemed to labor at times. The following day, however, it would stick on one end and then after an interval let go with a bang that shook the system. Finally it stuck permanently.

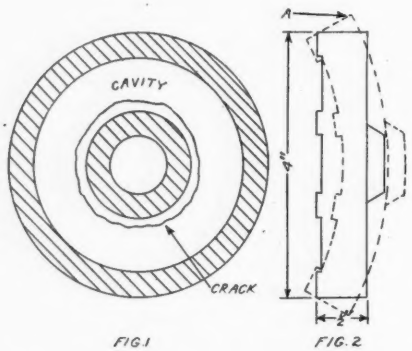


FIG. 1. VIEW OF FOLLOWER SHOWING CRACK
FIG. 2. DIAGRAM SHOWING DISHED FOLLOWER

After several attempts had been made to start it, the head was taken off, the follower nuts slacked back to hand tightness, and the checknut set up solid. The pump was then started, but with the same result; it stuck solid on the head end.

When the follower was taken off and examined, it was found to be dished, as shown in Fig. 2. There was also a crack running entirely around the center, and it was thought that the follower was a fit subject for the junk pile. In dishing, the inner edge, A, was thrown up, which, of course, increased the diameter, making it extremely difficult of removal. Pressure was put on this follower and it was pressed back flat again although being cracked nearly through all around we expected the center to be punched out. No accident occurred, however, and after the follower had been removed, it was put in a lathe and the edge squared up. No further trouble with this pump was thereafter experienced.

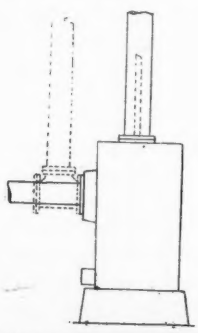
The foregoing incident illustrates what may result from packing a pump improperly. This follower, being only ½ in. thick and cracked, would, of course, not be able to withstand such a strain again, but with proper care in packing will continue to give good service.

A. C. WALDRON.

Simple Change in Piping Improves Heater Results

IN a colliery plant with which the writer was formerly connected, we had in service a direct contact feed water heater which was piped up as shown in solid lines on sketch, all the exhaust steam from the engines and auxiliaries passing through a 12-in. line into and through the heater.

Soon after putting the unit in service, and after getting the plant up to full load, we found that at periods of maximum load showers of water would be carried out through the vertical exhaust outlet, and we also noticed that at these times the feed temperature dropped off about 5 deg., doubtless due to the disturbance inside the apparatus.



CHANGE MADE IN HEATER OUTLET PIPING

It developed that the quantity of steam which passed through the apparatus at full load was far in excess of the steam required to do the heating—as a matter of fact, but one-sixth of the steam was needed for the feed heating—but the surplus steam surging through the apparatus picked up large quantities of the water which was being sprayed into the chamber, and carried it along with it, at the same time disturbing the heating action.

To remedy this, we decided to change the piping so that only sufficient steam entered the heating appa-

ratus to accomplish the heating. This piping change was easily made by making use of the existing vertical exhaust outlet, and moving it over to a 12-in. tee placed ahead of the heater, the full size outlet being replaced by a 2-in. line to carry off the air from the heater and insure a constant flow of steam through it. This piping change involved only the time necessary to make it, and the cost of the 12-in. tee, but it completely eliminated the trouble from water coming out the exhaust outlet, and an even temperature is also now maintained at all times.

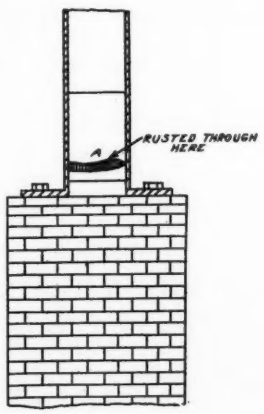
M. A. SALLER.

Rundown Steam Plant

IT IS surprising at times in what conditions some steam plants are operated without causing serious damage or accident to the plant.

As an example, I may relate the following: A manufacturing concern moved from one factory building into another which had recently been vacated by another manufacturing concern. When all the machines had been placed and operation started, it was found that the engineer, also being fireman, could not keep up sufficient steam pressure to pull the load. As the engineer was a new man it was at first thought that he was not well enough acquainted with the plant to be able to keep up the steam pressure; but as there was no improvement, in time it was decided that there was something wrong with the plant, for the power equipment was of ample capacity to pull the load easily, so the plant was shut down to make an examination of the entire equipment.

Starting with the engine, which is of the high-speed type, this was found to be in good condition; coming to the boiler, which is of the return tubular type, this was found badly scaled up, also the fire sheet was bagged a little. This was repaired and the boiler cleaned. In further looking for trouble it was found that the steel stack near the base where it rests on the brick stack



LOCATION OF CORRODED SECTION OF STEEL TANK

was rusted through badly as shown in the illustration at A, resulting in poor draft in the boiler furnace. After this and other repairs were made, the engineer had no further trouble in keeping up the steam pressure.

In this case the former owners and engineer of the plant were to blame in allowing the power plant to run down to the condition in which it was and the engineer taking charge of the plant for the new owners was also partly to blame for not giving the plant a thorough inspection before making an attempt to operate it, as there was sufficient time to do this before the factory was placed in operation by the new owners.

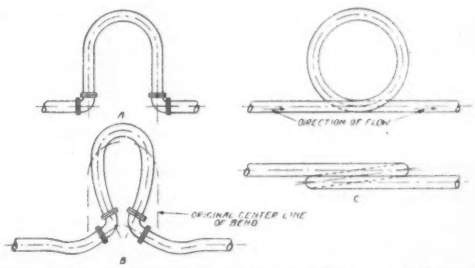
One reason that I am relating this is to warn some other engineer who perhaps will take charge of a steam plant at some time under the same conditions.

Do not take the other man's word entirely that all is in good condition. Inspect the entire plant yourself to find out for certain in what condition the equipment really is before making an attempt to operate it. Do this for the sake of "safety first" and your reputation as an engineer.

H. A. JAHNKE.

Stress in Pipe Bends

REGARDING Mr. Schaphorst's comment on the effect of thickness of pipe wall on the expansion taken up by pipe bends, the statement as to the effect of thickness of pipe material occurred in the original article, or a reprint of it. (I am not now sure which, as I only made an abstract of it for my notebook.) From the wording of the statement that these represent values



U AND PIGTAIL PIPE BENDS FOR TAKING UP EXPANSION STRAINS

of expansion which can be taken up without danger to fittings or adjacent piping, I judge Crane Company found the limiting factor to be the bending stress in the fittings or connections rather than in the metal of the pipe wall itself and it was to hold these stresses to an approximately uniform value that it was recommended to reduce the allowable compression in proportion to the increase in thickness of pipe wall since the stiffness, or force, required to cause a given compression increases in approximately this ratio.

Such stresses in fittings and flanges are by no means inconsiderable, as will be seen when it is considered that the same movement or leverage which acts at the full depth of the pipe bend to compress the bend acts with a very much shorter leverage and corresponding greater force on the flanges and connecting fittings.

For instance, consider a straight U bend inserted in a line with a pair of elbows. Cold, and in an unstrained position, this will stand as shown at A, the two ends of the pipe being in line, but when this is compressed it will assume a form somewhat as shown in B, the elbows being closed slightly and both bend and the ends of the line next the elbows assuming a reverse bend according to their stiffness. Anybody who has tried to bend a pipe of any size with a short hold in a vise, or once early in his career has tried to bend a pipe screwed into a fitting while holding the fitting only will realize how the strain is concentrated where the pipe joins the

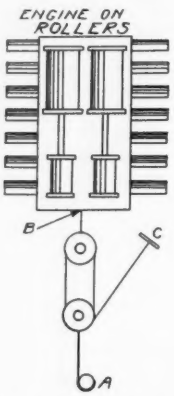
elbow and that the bending of the pipe at the outer curve of the bend takes place with a comparatively low stress in the material compared with those arising in the fittings and joints by which they are connected. It will also be obvious that for work of this kind only Vanstone or welded flanges which do not weaken the pipe at the joint should be used, as otherwise the stress will be concentrated in the reduced section of metal at the root of the thread with the possibility of final fatigue and cracking.

The action in the other forms of bends is similar though the example given is the easiest to visualize. A form of bend which has been comparatively little used in power house work since the two ends cannot conveniently be kept on the same level, but which will give greater expansion and less stress in the pipe than any other form for the same dimensions, is that shown in C and commonly known as a pigtail bend. This absorbs the expansion simply by increasing its diameter and as the circumference is over three times the diameter an increase of diameter of only 1 in. will take up over 3 in. in expansion. Also, as the curvature is all in one direction, the tendency to reverse bending and consequently greater stress is much less. Only one precaution is necessary: in horizontal runs always set the bend to drain in the direction of flow.

H. D. Fisher.

Moving a Nine-Ton Engine

Two or three years ago it became necessary, while installing a nine-ton semi-Diesel engine, to move it about 300 yd. over tolerably rough ground. At first it looked to be a difficult job; but when it was all over it seemed



MOVING ENGINE ON ROLLERS

so easy that we wondered why it had looked like anything at all. (Incidentally it was, in this case, impossible to construct any sort of rolling platform, and while a tractor might have been obtained to pull it, it was not thought advisable.)

First of all, the ground was gone over and smoothed as much as possible, the high spots being cut down, and heavy timbers being used to bridge low places and ditches.

Then a lot of heavy pieces of lumber, 4 by 8 or thereabout, were secured, and laid before the engine, and taken up after it had passed. These formed a very good temporary floor on which it rolled pretty well.

At the first of the run, where the ground was very bad, the fastest it was safe to go was to move the engine by setting three heavy jacks behind it and raising them slowly. In this way it was moved over the first hundred yards in a day. The rest of the ground was comparatively smooth, so a rig was fixed up as shown in the diagram.

The point A represents a steel stake driven in the ground, to which the stationary block was attached. The other block was then fastened to the engine at B, and a mule hitched to the rope-end at C. This arrangement proved satisfactory, and the engine was moved on to its place.

Here it was raised from the floor by a 20-T. (capacity) hoist, suspended from a specially built scaffold. (The roof wouldn't have held it up.) A bonehead mistake was made which caused the engine to be lowered too soon, and almost ruined the foundation bolts; however, with a little work they were made to do, and the engine was securely fastened to the foundation.

Acker Petit.

Steam Used by Soot Blower

C. C. Brown publishes some very interesting matter under the above title in the March 1 number of Power Plant Engineering, page 284, but he omits the most important part, namely, the cost of blowing the soot off the tubes and the actual dollars and cents saving per year due to the installation of a mechanical blower.

For example, if he had given the efficiency of the boiler with the soot blower installed and again the efficiency of the boiler as it would average without the blower or using the ordinary hand method of cleaning, it would be a simple matter for non-users of soot blowers to decide whether or not it would be profitable for them to invest in such blowers.

The writer has done a little figuring "on his own hook," using Mr. Brown's figures, on the assumption that with the soot blower installed 6 lb. of steam are generated per pound of coal, and on the further assumption that a ton of coal of 2000 lb. cost $5 a ton. On that basis the cost of blowing the soot, at each blowing of 3 min. duration, would be as follows:

Initial Steam Pressure Lb. Gage	Cost for Cleaning
150	$ .96
200	1.42
233	3.60
235	3.70

Often, however, three cleanings are required per day where soft or very sooty coal is burned and in that case the cost of blowing off the soot per day of 24 hr. would be approximately:

Initial Steam Pressure Lb. Gage	Cost of Cleaning	Cost Cleaning per year of 300 days
150	$2.90	$870
200	4.25	1270
233	10.80	3250
235	11.10	3330

To be sure, the number of working days, efficiencies, etc., may be different; but, following this method, and knowing the size of the boiler and the total amount

of money spent for fuel per year, it becomes a comparatively simple matter for the boiler owner to estimate with fair accuracy the cost of blowing the soot from his boiler tubes per year. However, since Mr. Brown's data are incomplete, it will be necessary for the boiler owner, operator or engineer to make assumptions; hence it would have been to the advantage of the readers of Power Plant Engineering if Mr. Brown had given more data concerning his interesting and important subject.

W. F. SCHAPHORST.

Spineless Engineers

I HAVE read H. A. Cranford's article, "Spineless Cactus," in the April 1 issue. No doubt there are a few engineers such as he describes; personally, I believe they are the exception rather than the rule.

I talk with many engineers and, to use an old saying, the shoe seems to be on the other foot. Some employers will employ a consulting engineer, a self-styled expert, and pay him good money for information the engineer could have secured for his employer if he had been given the same privileges placed at the expert's disposal.

Employers are learning that the modern engineer is something more than an ordinary workman and mechanic, that he is a man of wide and varied knowledge and that it is good business policy to consult with him as the real engineer is of a different class from the old engine runner; he is a practically recent product of the engine room and power plant, technical school, correspondence school, and technical journal combined. Some employers have not yet awakened to the fact that they are employing an expert in the fullest sense of the word, a man whose knowledge often extends a considerable distance into the different paths of science; they still class their engineer as an ordinary mechanic.

Of course, there are exceptions; some men will not study or work any more than necessity compels them. I have known operating as well as consulting engineers who were 10 per cent ability and 90 per cent bluff; this is no reason for condemning or placing them all in one class.

As a rule the present-day employer is most likely to consult his engineer before he makes changes, even minor ones, in the power plant. Take it all in all, the spineless engineer is mighty hard to find and will soon be an extinct species.

JAMES E. NOBLE.

Low Liquid in Storage Batteries

STORAGE BATTERIES are sometimes overcharged through ignorance or lack of attention to such an extent that the expulsion of electrolyte by gassing leaves two-thirds of the plate surface uncovered. When this occurs, the active material on the negative plates is oxidized by the oxygen evolved by electrolysis within the cell. This brings about the discharge of the plates as effectively as if it occurred in a nominal way, except that the discharge takes place far more rapidly and is probably carried to zero.

An analysis of the matter will show that when the battery is filled up with electrolyte, two-thirds of the plate surface is dead. The only method of correcting this trouble is to give the battery an amount of overcharge such as would be necessary if the entire cell had been discharged to zero. It is desirable that it should receive this amount of overcharge all at once but if this cannot be done, it may be given in two or three installments.

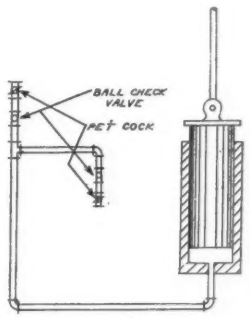
The battery should not be worked hard until fully restored, as the current drawn from it comes from only one-third of the plate surface.

When the water level does not fall as low as assumed in the above case, it will still be necessary to give the same amount of overcharge in order to restore that part of the plate surface above the level of the electrolyte, but the precautions regarding the withdrawal of large currents may be disregarded to some extent.

T. H. REARDON.

Curing Dashpot Troubles

"CURING Dashpot Troubles," in the March 15 issue, by M. M. Brown, reminded me of a way in which I cured troubles on two occasions. I closed all outlets on the dashpot except one on the bottom of the pot,



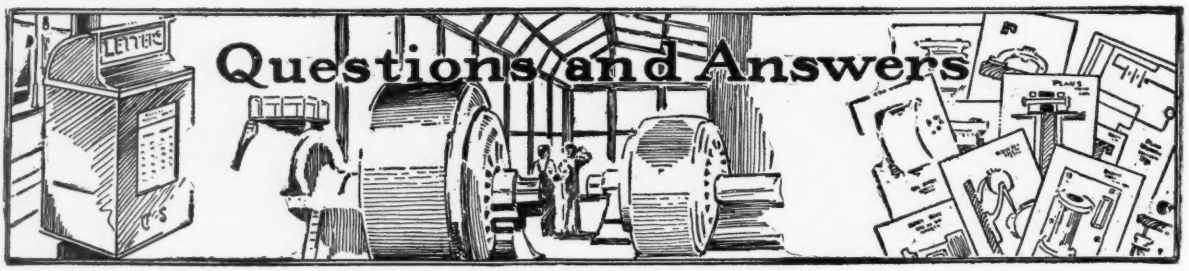
USE OF PET COCKS AND CHECK VALVES ON DASHPOT

into which I screwed a ¼-in. nipple and then made pipe and fittings up as shown in the sketch. By turning the handle lower on pet cock, you can get vacuum desired and turning the handle on top pet cock gives you cushion desired.

I have a Corliss engine in which the dashpots were worn so that they could not be adjusted, and tried this scheme and they have been running ever since. I had to renew check valves once in this time. I do not know of anything cheaper or that will give more satisfaction than this arrangement.

WM. SCHOCH.

U. S. CIVIL SERVICE COMMISSION announces an examination, applications to be rated as received until June 1, for junior engineer, to fill vacancies in the Water Resources Branch of the Geological Survey at entrance salaries from $1440 to $1740 a year, and in positions requiring similar qualifications, at these or higher or lower salaries. In addition, employes will be allowed expenses when on field duty. Appointees whose services are satisfactory may be allowed the increase granted by Congress of $20 a month. Appointees will be assigned generally to the work of gaging streams and the study and investigations of water supply, water utilization, and power in the United States. The work will consist of field investigations and the writing and review of the resulting reports. The field of investigation may be in any part of the United States. Applicants must have reached their twentieth but not their thirty-fifth birthday on the date of making oath to the application.



What Causes Air in the Water Supply System?

WE HAVE recently been having trouble with our town water supply and as yet I have been unable to locate the trouble. I would appreciate comments from readers of Power Plant Engineering as to how I should correct the trouble.

Lately the water in most of the faucets comes out full of minute air bubbles, which gives it a milky look. Two faucets in the same building will not be the same, however; one will deliver this milky water while the water from the other will be almost clear.

Our well is approximately 125 ft. deep with about 96 ft. of pipe above the cylinder. The supply tank is 118 ft. high to the maximum water level. The mains are 4 in. and circulating with the exception of four blocks of piping, each of which has one dead end. The pump is 6 by 24 in., making 12 strokes per min. and is driven by a 15-hp. oil engine.

I have tried slowing down the pump; but that does not seem to have any effect. I have examined the water in the tank and it appears to be perfectly clear as far down as I can see (not less than 8 ft., I should say), yet we can empty half the tank (20,000 gal.) through the faucets and the water will continue to be milky. I had thought that possibly the pump cylinder was above the level of the water in the well and that the pump was getting air through a leak in the pipe between the cylinder and the well; but if such were the case, it would seem that the air would be released in the tank and that the water would come through the faucets clear.

What causes this trouble and how can it be remedied?

R. J. W.

Effect of Counterbore

IN ANSWER to "What is the effect of counterbore?" by F. R. B., April 15 issue: It is not absolutely necessary to have a counterbore insofar as the operation of the engine is concerned, but it is desirable for these reasons. In the alinement of an old engine, the cylinder bore of which may be worn, the measurement is taken from the counterbore; the counterbore centers the boring attachment when reboring a cylinder, and also prevents a shoulder forming in the bore by allowing the piston ring to lap over the end of the cylinder bore at each end of the stroke.

In F. R. B.'s case, the absence of a counterbore should not cause a pound; the cylinder, being newly bored out, there should be no shoulders for the piston ring to strike against. The fact that his engine did not pound until he had the piston fitted with new bull and steam rings would seem to point toward the bull ring.

I had a new tandem compound Corliss engine which developed a pound shortly after being put in service. After running down all probable causes, I was convinced that it was in the low pressure cylinder. On opening it and taking off the follower plate and making some measurements, the cause seemed to be that the follower did not pinch the bull ring tight enough. We planed off the follower where it came in contact with the piston spider enough to allow it to pinch the bull ring and still have 0.0001 in. to go before coming in contact with the piston spider. It was then drawn up to the spider. This was a 34-in. cylinder. The pound was gone upon starting the engine, and has given no trouble since.

If F. R. B. would examine his piston, I think he would find the trouble; his bore being but 16 in., he should not spring the follower more than 0.003 in. to avoid the possibility of cracking it. I. F. RICHMOND.

Evaporator Capacity

WILL YOU kindly advise me how many pounds of steam per hour would be evaporated in an evaporator consisting of a drum with a submerged heating coil containing 50 sq. ft. of 1¼-in. piping? There is 80 lb. steam pressure on the heating coil and 18 in. vacuum on the evaporator. W. G. M.

Boiler Backfires

WHAT CAUSES a hand-fired boiler, burning shavings, to backfire?

At our plant we have a battery of horizontal return tubular boilers. Number two boiler, which is nearest to the stack, always backfires after a fresh firing of dry, hard wood shavings. Accidents have occurred on this account in which firemen have been badly burned. When a backfire occurs it throws all the doors open, even those on number one boiler.

Although there is no damper in the stack, there is one in the uptake. The stack is 100 ft. high, 4 ft. in diameter at the top. The boiler size is 72 in. by 18 ft. G. P.

Interpretation of Forces Acting on Engine Piston

FROM AN indicator card taken from a cross compound engine in our plant, it can be seen that there is a pressure of about 2.5 lb. on the low-pressure cylinder at the point of admission which is, of course, effective in moving the piston. During the course of expansion, the pressure drops below atmospheric and we start to get a vacuum. What I would like to know is this: Is the steam still pushing the piston after the expansion line has dropped below the atmospheric line or is the vacuum on the other side of the piston depended upon to pull it along?

H. S.

A. The only logical way of picturing the forces acting on the piston in a steam engine is to consider the net force acting in one direction, as it is the difference

between the force acting in one direction and that acting in the other which is effective in producing motion. Unless there is a perfect vacuum obtainable, i. e., absolute zero pressure, there is always a force acting on both sides of the piston and it is the difference between these two forces that should be considered. To get a clear idea of the action, a vacuum should not be considered in a negative sense; that is, it should not be considered as a suction, but rather as a reduction in back or resisting pressure.

On an indicator card this force may be represented by a vertical line drawn from the expansion line on the head end, say, to the exhaust or compression line on the crank end. In reality the length of this line is the difference in lengths of a line from the expansion curve to absolute zero pressure. It will be seen that at certain points of the stroke this force acts against the piston motion. If we represent forces acting in the direction of motion of the piston with an arrow downward, the

SIMPLE NON-CONDENSING ENGINE INDICATOR DIAGRAM SHOWING LINES OF NET FORCE DRAWN IN

lines, which will always point from the steam to the exhaust line, will point down until the compression line crosses the expansion line, after which they point up until the end of the stroke. The area covered by lines pointing up represents work being done by the piston in compressing the steam and is a loss.

The accompanying illustration shows a diagram from a simple noncondensing engine on which these force lines are drawn in. If the two diagrams from the two ends of the cylinder are symmetrical, it may be demonstrated that the algebraic sum of the areas covered by the arrows is equal to that of the card as ordinarily taken.

Furnace Radiation Losses

IN ANSWER to the question raised by C. P. D. on page 487 of the May 1 issue of Power Plant Engineering, concerning the deterioration of furnace radiation losses, it may be said that there is but little information available that would enable one to determine this loss beforehand. It is instead, usually found by experiment as difference between known quantities in a heat balance test.

Various authors give different figures as to the amount of this loss, which vary from as little as 2 per cent to as much as 6 per cent of fuel fired, at rated capacity. In every case the loss is found by subtracting from the heat supplied by the combustion of the coal, that absorbed by the boiler, the loss due to evaporation of moisture in coal and in the air, that due to formation of steam by the combustion of hydrogen, the loss due to heat carried away with the flue gases, the loss due to carbon monoxide, and combustible in ash. This loss is that due to unconsumed hydrogen and hydrocarbons, to radiation and otherwise unaccounted for. That part of this item of loss which is due only to radiation can be fixed only by conjecture founded on experience.

Sometimes the ratio of the amount of coal required to keep up pressure in a banked boiler to that consumed in the course of normal operation is assumed as the percentage of loss due to radiation, but such is not the case. In the first place, the fuel is burned with an insufficient supply of air and at a comparatively low temperature. As a result much carbon monoxide and but little carbon-dioxide is formed, the hydrocarbons distilled off are but partially consumed and therefore only a portion of the potential heating value of the fuel is realized, yet the loss is all called radiation. On the other hand, the furnace temperature is low and consequently the actual radiation is less.

Radiation does not bear the same relation to heat supplied at all rates of driving. Whereas the actual radiation increases with increasing load, the radiation per unit of output decreases as the output increases because the output increases faster than radiation. That is, at zero output with the boiler banked, the radiation per unit of output is infinite and as the output increases indefinitely the radiation approaches zero per unit of output. As the load increases, the flue gas temperature increases, so that it may be said that the radiation per unit of output varies inversely as the uptake temperature.

Radiation is, of course, dependent on the extent of furnace surface, thickness and construction of walls, conductivity of the materials used, arrangement of the individual boilers in the battery temperature of the boiler room, etc. In this respect, it may be observed that if the air necessary for combustion is taken from the boiler room, the heat lost through the furnace walls may be in a large measure recovered and hence the net loss may be reduced.

Knowing the furnace surface, the thickness of the walls and the coefficient of conductivity of the brick and tile, it might be assumed that the radiation could be calculated; but when it is considered that it would be necessary to know the temperature of the furnace gases at each square foot of the entire surface and the amount of heat received by direct radiation from the fuel bed, it will be seen that the job is no child's play. At any rate, there has, so far as we know, been no authentic determination made.

Oil Hole in Crankpin

WE HAVE an engine without a center oiler on the crankpin and intend to install one. We are at a loss to know how to drill the hole from the center of the pin

COMMON LOCATION OF OIL HOLE IN CRANKPIN

to the bearing surface and would be pleased to have you inform us what is the usual practice. A. C.

A. General practice seems to favor drilling this hole parallel with the center of the crank arm from the outside surface to the center of the crankpin, thus the flow is in direct line with the centrifugal force. The sketch shows one system.

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Calumet Station

The problem of providing an adequate supply of condensing water is always a matter of considerable importance in the design and construction of a steam generating plant; in fact, in the case of large central stations, this problem is often a deciding factor in the selection of a site for the plant. While cooling ponds or cooling towers often provide a way out of the difficulty in the case of industrial power plants, the tremendous quantities of cooling water required by large central stations does not admit of this method being used in the latter class of plants. Central station requirements demand a constant natural source of cold water supply and for this reason such plants are invariably located adjacent to a river or lake.

In the matter of condensing water supply, attention is directed to the peculiar problem which confronted the designers of Calumet station. Although the flow of water in the Calumet river was ample to satisfy all the needs of Calumet station, the situation was complicated because of the tendency of the river to reverse its direction of flow at times. This peculiarity of flow, obviously, would create unfavorable operating conditions unless an arrangement were provided whereby the relative positions of the intake and discharge channels might be transposed at will.

This reversing tendency is, of course, exceptional with the Calumet river but it is, no doubt, a matter of interest to engineers to know just how the solution to this problem was effected. This is fully described in the article on Calumet station in the current issue.

Another feature of interest at Calumet is in the arrangement of the high tension busses. In ordinary practice, the three phases of a bus are located adjacent to each other. That is, if there are two separate busses, the A, B and C phases of one bus will be installed on one side of the room and the A, B and C phases of the other bus on the opposite side. At Calumet, however, the three phases of each bus are widely separated. The two A phases of each bus are located on one side of the room, the two B phases in the center and the C phases on the opposite side. This arrangement obviously eliminates the possibility of short circuits between phases to a high degree.

The separation of phases in this manner necessitated the use of special switching mechanism and the paralleling mechanism employed to actuate the circuit breakers on the three phases simultaneously marks an entirely new development in circuit breaker practice.

The trend towards simplicity in power plant design is clearly reflected in Calumet. When one pictures the typical engine room of twenty years ago with its multiplicity of piston rods, eccentrics, dashpots, flywheels, etc., and then notes the simple elegance of the spacious turbine room at Calumet, it seems strange that we did not come to the simpler arrangement first. The simplest design, however, is always the most difficult and requires the most skill, and in Calumet there is incorporated the accumulated knowledge and engineering skill evolved since the invention of the steam engine. Most of the good features of previous stations as well as a number of new ones have been put into this power station. The result is a station of maximum simplicity, economy and reliability.

Making the Boiler Room a Laboratory

How many times have you, during arguments with fellow engineers, declared that your conditions of operation were so entirely different from the other fellows' that their methods would not get results in your plant? And each time you presented that as an excuse for not getting better results, nine chances to one you were advertising your inability as an engineer. The man who knows that these differences exist should also know what they are and their relative effects on operation, and such a man will not hide behind a general statement but will present definite facts and figures to prove his claim.

No two power plants are alike in every respect, particularly when it comes to operation. The manufactured equipment is usually standard in design and materials used, but the arrangement of this equipment in the plant calls for individuality in piping, wiring, lighting, safety devices and many other details that go to make up a power plant. Then we have the individualities coming from the location which governs, to a large extent, the kind of fuel used, the amount and quality of water available, the weather encountered, the character of load carried and the quality of help obtainable.

Each individuality is a problem in itself. Perhaps some other plant has worked out a solution to a particular problem and the results are obtainable for use, or the method of solution may be applicable in the plant in question so that it is not necessary to devise an original solution; however, no matter what they may be or how they may be obtained, the characteristics of each plant should be determined to such an extent that the operating force will know how to cope with any normal change in condition.

For this reason the leading power plants of the country are being turned into practical laboratories for the investigation of the effects of changes in operating conditions and on other pages of this issue are presented the results obtained by Messrs. Joos and Binns in one boiler room where the causes of priming were investigated. In this work the ordinary power plant instrument equipment was used, but the results obtained are sufficiently accurate to guide those in charge of operation and point the way to the elimination of priming. Work of this character is bound to give rewards in increased economy and safer conditions.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Ten Success Hunches

By Dr. Frank Crane

A VERY human letter lies before me. "I read your editorials," says the writer, a young man, "and have been especially interested in those that touch upon ambition and opportunity.

"Now I would like you to answer me just one question. What is a young man to do when he reaches the age of twenty-one with no special training? He has lots of ambition, besides ability to work, but he finds that this talk about courage and will power is nothing but rot. For wherever he seeks an opportunity to start from the bottom, no one pays attention. The very men who preach opportunity and rising to high positions in life by hard work, refuse to make a place for him. They tell you about using your brains, but at the same time they don't give you a chance to use them. Can you explain how in the world there is any opportunity in such a case"?

Well, in the first place, living all those years until twenty-one without training, is a crime. But perhaps it was not your fault. If you ever have children, however, see that you do not wrong them as your parents and the state, and possibly yourself, wronged you.

Still, at twenty-one you have the world before you. Perhaps these hints may help you:

1. Don't be impatient. It's a life job you're tackling. Set your jaw. Plan for years, not for tomorrow only.

2. Remember that your real success takes place inside of your mind. It's not facts, nor others' acts, nor events, that matter. Nothing matters in the long run but the temper of your spirit. Keep *thinking* success; and the more you are rebuffed the harder you must think it.

3. You seem sorry for yourself. That looks bad. Flee thoughts of self-pity as you would the devil. Are you alive and kicking, and have you a clear head and two good hands? If so, you're in luck.

4. Study. I'll venture to say you waste enough spare time in four years to make a doctor's degree. Find out what you want to do. Say it's engineering. Take up a course of study in that direction.

5. Do well what you can find to do. Do it better than anyone else can do it. Do it—and keep your eyes open for something better. Be efficient. Every factory, store and farm in the world is hungry for the man who can do the business and not make excuses.

6. Don't fret. Don't worry. Have faith. Believe in yourself. Believe in the world. Believe in the Eternal Justice. If you do, the stars will fight for you; and if you don't believe, if you complain and get it into your head that this world is down on you, why, it *will* come down on you and *smash* you, and you'll get what you believed in; everybody does.

7. Be persistent. Fortune's a fickle jade. If she does not say, "Yes" the first five times you ask her, *ask her twenty-five times.* After a while she will favor you, for she loves importunity.

8. Get the luck idea out of your head. There is such a thing as luck; but that is not what you are looking for. What you want is *success,* and there's no luck about that; it's just as certain as the corn crop to those who know how to raise it.

9. Don't expect anything of anybody but yourself.

10. Be cheerful. It's all in a lifetime. Meanwhile there are doughnuts and coffee. And the pleasant sun is shining. I expect you are missing a lot of happiness because you don't know it when you see it.

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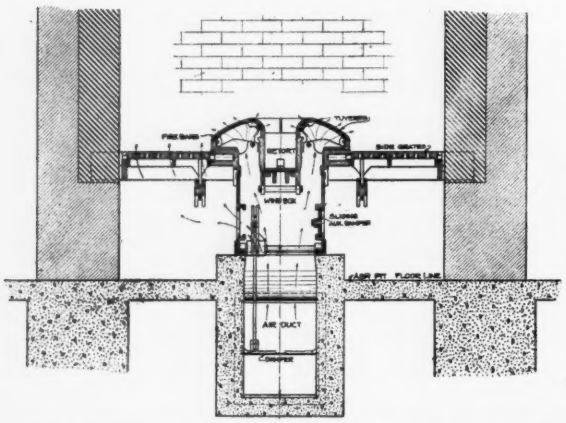
Type K Underfeed Stoker

AFTER an experience of two years in supplying underfeed stokers for relatively small boiler installations, and at the same time studying the various conditions of operation, the Combustion Engineering Corp. has placed on the market a new type K underfeed stoker, in the design of which there has been incorporated a number of changes.

As is the case with all stokers of this general design, the coal enters the feeder box from a stoker hopper. Thence it goes to a deep feeding trough extending the length of the stoker. At the bottom of this retort there is a sliding plate carrying a series of pusher blocks which is operated through a crosshead from the piston rod of the steam cylinder which, by its reciprocating action, conveys green coal under the fuel bed.

As the green coal is being forced upward, the gases are distilled off and the coal ignites. At this point air is admitted, as shown in the accompanying illustration through tuyeres in the fire box, to support the combustion. Thus the live coal passes over the fire bars and is deposited on the side grates which may be of either the shaking or dumping types. The grate tops have circular air opening for supplying draft to the coke on this



SECTION THROUGH TYPE K SIDE DUMP UNDERFEED STOKER

portion of the grate. By this arrangement, additional active grate area may be utilized for peak loads.

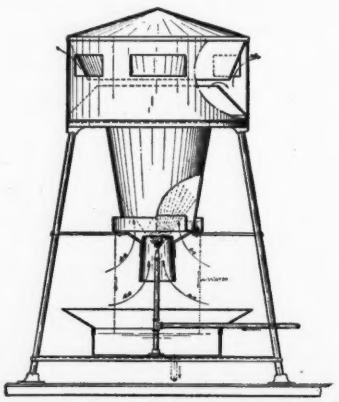
Both stoker and fan engines as well as the damper may be controlled by a valve which is operated by steam pressure; however, provision is made for manual control of the stoker. The stoker cylinder is made of such size that it can satisfactorily be operated on steam pressures as low as 50 lb.

Induced Draft Cooling Tower

A NEW principle of operation is embodied in the design of an induced draft spray tower recently placed on the market by the Binks Spray Equipment Co. for cooling relatively small quantities of water. The accompanying illustration serves to show the general construction and operating principle.

Essentially the apparatus consists of a spray nozzle in a throat located immediately below a short chimney or stack. Above this is a system of baffling which serves to prevent loss of water by entrainment.

In operation a draft is produced through the stack by reason of the inductive effect of the spray and the chimney action of the stack. The air in passing through the spray attains a greater degree of saturation and the water by evaporation is cooled to within a few degrees of the wet bulb temperature. The partially cooled water collects on the inside walls of the stack and drains down into a circular trough at its lower end. Through holes in the bottom of this trough the water rains down across the current of incoming air, where it is further cooled, and is collected in a sump tank below. From here it is pumped back through the apparatus, whatever it may be, from which it is desired



BINKS SPRAY TOWER SHOWING PRINCIPLE OF OPERATION

to abstract heat. This apparatus may be an ammonia or CO_2 condenser, or it may be an air compressor, gas engine, oil cooler, transformer or any such water cooled equipment.

By means of substituting a spray nozzle of desired capacity the tower capacity may range from 10 to 60 gal. per min. for a nozzle pressure of 10 to 15 lb. The overall dimensions of the stack remain fixed regardless of capacity.

In refrigeration work, assuming 4 gal. of condenser water per ton of refrigeration, the tower takes care of capacities of from 2 to 15 T.

The tower is constructed of sheet zinc, which is rust proof, and is supported on an angle-iron frame. The catch basin is of galvanized iron. The whole weighs in the neighborhood of 400 lb. and may be placed on a roof without using extra supports.

Small Capacity Refrigerating Unit

A SMALL CAPACITY ammonia refrigerating unit designed for light refrigerating loads such as cooling drinking water in industrial plants, refrigerators in hotels and markets, has been lately added to the list of products of the Norwalk Iron Works. The machine constituting the complete high pressure side of the system, i.e., excluding only the expansion coils, is assembled as a single unit, thus eliminating to a large degree erection supervision.

The smallest unit has a capacity of ¼ T. per 24 hr. The compressor is of the two cylinder vertical type, size 1⅜ by 1½ in., single acting, speed, 425 r.p.m. It is chain driven from a ½ hp. motor which is mounted beside the compressor, on the condenser frame. All

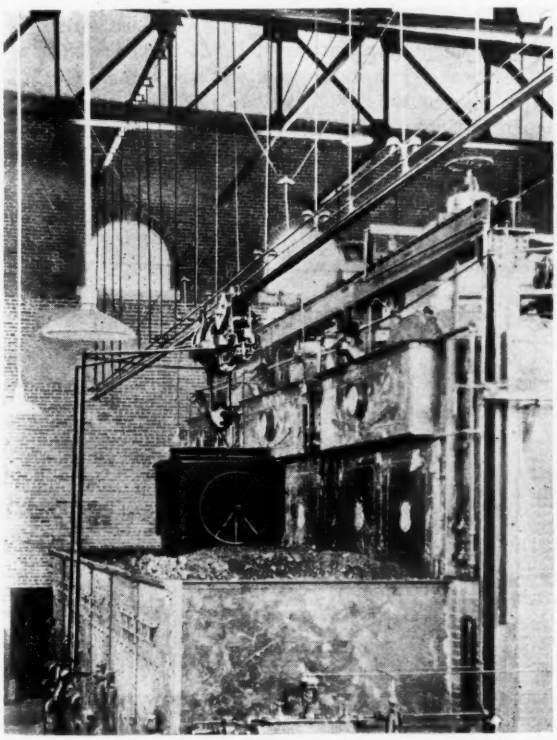
valves and gages are provided on this mounting so that there remains only the expansion piping to make a complete installation.

Tramrail System for Handling Materials

IN POWER PLANTS where current is generated by the use of steam, one of the important items of expense is the unloading, storage and supply of the coal. When we consider that the many advantages to be gained by the storing of coal at the right time may be entirely offset by poor and inefficient methods of storing and handling, it will not be amiss to consider the possibility of saving at this point.

In most plants ground space is at a premium while the overhead space is little used, except where the conditions permit of a crane installation. The answer to this problem seems to point to the overhead method of handling.

There has recently been brought out by the Cleveland Crane & Engineering Co. an electric tramrail



ELECTRIC TRAMRAIL LOADING COAL INTO FURNACE BIN

designed especially to meet this situation. This tramrail operates overhead and is able to reach into every corner of the coal storage and the boiler room. It may be used to unload coal directly from the cars, to fill hoppers from the storage pile, to remove ashes from the boiler room and when desired can be used to handle machine parts, supplies, etc.

The accompanying illustration of this tramrail shows it placing coal in a furnace hopper. The feature of this system is the flexibility of the installation of the rail. The extent to which this flexibility has been developed is shown by the methods of suspension, which consists of hanger rods, brackets and rail clamps, which can be attached to the purlins of a building or to almost any support available.

By use of cold bends in this rail, any corner or curve down to a 4-ft. radius can easily be made without sacrifice of safety.

A clever type of switch employed is the sliding switch designed especially for this tramrail. Like the other units of the system, these switches are standard. Whether for hand power or electric, the same switch is installed, which permits the hand power system to be electrified at any time. In action, this switch makes but little noise on account of the fact that both stationary and movable rails are held in firm contact, eliminating the open space at the point where the rails join. Safety is given special attention at this point, with the result that the instant a switch is opened a safety stop drops on the rail, preventing the carrier from passing that point, and when the switch is in position it is automatically locked, which prevents the carrier and its load from sliding the switch out of alinement. An additional safety feature, the installation of a trolley wire insulator, makes it impossible for an electrically driven carrier to run at full speed against a safety stop or open switch.

In the installation of this system it is often found necessary to install the rail at different levels, which means that the carriers must travel a grade. Up to a grade of 12 per cent the electrically driven carrier has ample power to operate with full load. This, of course, makes the employment of a foot brake quite essential. Where the difference in levels is greater than it is practical to climb, an ordinary freight elevator is installed with the tramrail. This method safely lifts or lowers the carrier and its load to the desired level without rehandling.

By the use of a central control system, several carriers can be operated by one man, located at an advantageous point, from which an unobstructed view of the system is possible, or if this is impossible, the operator is informed as to the location of the carriers he controls by signal lights on a board before him. With this arrangement the dispatcher can switch the carrier to any track or location desired.

An important innovation of this system is the manner of installing the tramrail transfer bridge, which gives accessibility to every point on the floor. A standard rail, installed along the length of the building on both sides, forms the runway for the transfer bridge, which permits the carriers to operate from the tramrail track onto the bridge.

New Type of Air Break Switch

A NEW TYPE of manually operated, non-automatic, single-throw horn gap switch for outdoor service has been developed by the Westinghouse Electric & Manufacturing Co. The switches are made for capacities up to 200 amp., 66,000 v., alternating current.

The type T, horn gap switch, which is in reality a manually operated, non-automatic, single throw, air break circuit breaker for mounting on top of poles or structure, is used primarily for outdoor service under all weather conditions. This switch can be used in

many cases for switching power loads, changing transformers from line to line, etc., where the expense of the more costly oil circuit breaker is not warranted. Its principal fields of application are in switching at substations to cut off the transformer banks from the transmission line; for line sectionalizing; controlling branch feeders from the main transmission line; controlling individual consumers' installations, etc. These switches are designed to rupture 1800 kv.a. of transformer charging current at normal rated voltage.

The two fundamental considerations in the selecting of air break switch equipment for a system are, first, the ability of the switch itself to interrupt the circuit successfully, without undue damage to the switch itself;

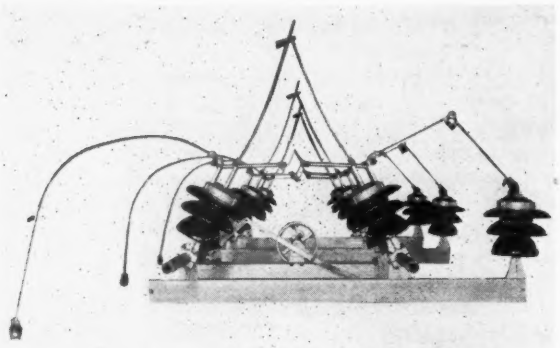


FIG. 1. TYPE T, HORN GAP SWITCH IN CLOSED POSITION

and second, the effect of the switching operation on the line and equipment generating and using the energy transmitted.

When a circuit carrying low or high tension current is opened, an arc is established. Means must be provided for breaking this arc in order that the current cease to flow.

In oil circuit-breakers, the oil quenches the arc by cooling it, and by quickly flowing between the contacts.

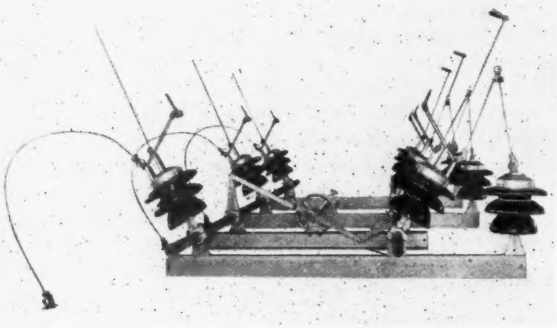


FIG. 2. TYPE T, HORN GAP SWITCH IN OPEN POSITION

This action is increased by pressure of the oil above the arc.

In air, however, it is much more difficult to extinguish the arc since the air, as an arc rupturing medium, is not nearly as good as oil. One means of quickly extinguishing an arc in air is by the assistance of a magnetic blowout. When magnetic blowouts are not used, the usual way of breaking the arc, is to stretch it to such a length that its resistance is sufficient to counteract the line voltage. This often requires stretching the arc to a relatively great length before it is broken.

The length of the arc can seldom be measured by the shortest distance between the two points from which it emanates; as the arc almost always forms a loop which takes all kinds of shapes according to the air currents.

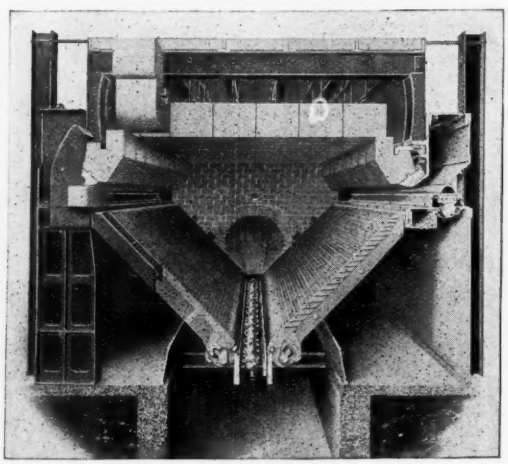
These switches open in a vertical plane parallel to lines, thus not shortening spacing between live parts when switch is opened.

The arc is drawn from tips of auxiliary contacts high up above all grounded parts to eliminate striking to ground. The arc does not climb up the horns, but is started at the tips of the horns and is quickly stretched to maximum straight length. From this point, if the arc continues, it will rise or be blown to one side until it finally ruptures. This length is so great, however, that the arc is generally extinguished before the end of the opening movement of the auxiliary contacts.

M. I. W. Suspended Arch

THE M. I. W. suspended arch, a furnace lining recently developed by the Murphy Iron Works, was designed to eliminate some of the inherent defects normaly found in such arches. The form shown in the accompanying illustrations is of the flat suspended type, but the idea is adaptable to almost any form.

The arch consists of a number of slotted blocks each independently hung from longitudinal pipes which are in turn supported from transverse I-beams. This pipe has a series of perforations near the rear and is open



CROSS SECTION OF BOILER FURNACE SHOWING M. I. W. ARCH INSTALLATION

at the front. The furnace induces a current of air through these pipes; thus keeping them cool and at the same time delivering it in small jets at points where the cooling effect is needed.

As each piece of tile is independently supported from the pipe, any brick may be removed and replaced without disturbing the surrounding tile. Such replacements may even be made while the furnace is in operation by simply removing the cover tile and raising the defective block by its hook. Another feature lies in the fact that the supporting hook may be shortened so as to bring the surface of the new tile flush with that of the undersized adjoining pieces.

With this method of suspension, there is no pressure between the blocks, consequently the occurrence of expansion checking and spalling is eliminated to a large degree.

Exhibit of Power and Mechanical Engineering Machinery in New York

BEGINNING during the meeting of the American Society of Mechanical Engineers and continuing for a week, an exhibition of machinery is to be held at the Grand Central Palace in New York, Dec. 7 to 13, except the intervening Sunday. Its objects are to bring together manufacturers, engineers and capitalists for exchange of ideas and study of the latest developments, to arouse the interest of the public in conserving fuel and furthering economy in manufacturing and construction processes and to spread knowledge of labor-saving machinery.

That it will be more than simply an advertising exhibit of machinery is insured by the names of the men behind the movement. These include the president of the A. S. M. E., Dexter S. Kimball; the president of the N. E. L. A., Milan R. Bump; the national vice-president of the N. A. S. E., Fred Felderman; and an Advisory Committee of which I. E. Moultrop, of the Edison Illuminating Co., of Boston, is chairman. Others on the advisory committee are such noted engineers as N. A. Carle, A. G. Christie, E. B. Katte, Fred R. Low, David Moffat Myers, Calvin W. Rice. The managers of the exposition are Fred W. Payne and Charles F. Roth, with offices in the Grand Central Palace, New York, to whom requests for information and reservations of space should be made.

Refund of Unpaid German Money Orders

POSTMASTER LUEDER of Chicago announces that the German government is now authorizing refunds on money orders which were issued in the United States for payment in that country, but which were never paid on account of conditions caused by the war. Hundreds of these authorizations for repayment have been drawn since the recent resumption of correspondence with the German Postal Administration in the interest of the remitters.

As many of the original remitters cannot now be found on account of the lapse of time or the non-preservation of the original records, the postmaster states that it would be well for the remitters of such orders issued during the year 1916 or about that time, which there is good reason to believe were never paid, to present the original receipts or other evidences of the transactions at the post office or at the carrier stations where the orders were purchased.

The issue of new money orders on Germany has not yet been provided for on account of the unstable rate of exchange and other financial difficulties, and the above refers only to wartime transactions preceding the entry of the United States into the conflict.

THERE'S TROUBLE enough in your vicinity without looking for it.

News Notes

THE ANNUAL convention of the American Boiler Manufacturers' Association will be held June 5, 6 and 7, at Buck Wood Inn, Swanee on Delaware, Pa.

THE STOKER MANUFACTURERS ASSOCIATION has plans well under way for its meeting at Groton Point, Conn., which will be held June 19 to 21. Details of the program will be given later.

THE SECOND EXHIBITION of power plant equipment and mechanical appliances will be held on Chicago's Municipal Pier June 7, 8, 9 and 10, 1922, far surpassing the one of last year.

SEMI-ANNUAL meeting of the American Society of Heating and Ventilating Engineers will be held in Buffalo, June 6 and 7, and Detroit, June 8 and 9, the meeting moving from Buffalo to Detroit by steamboat the night of June 7. Headquarters in Buffalo will be at Hotel Iroquois and in Detroit at Hotel Wolverine.

THE LONDON STEAM TURBINE Co. announces the removal of its main office and works to its new location at Troy, N. Y.

THE QUAKER CITY RUBBER Co., of Philadelphia, has removed its Chicago offices from 182 W. Lake Street to 215-225 West Huron Street.

EFFECTIVE APRIL 17 the name of the Wayne Oil Tank & Pump Co. was changed to Wayne Tank & Pump Co. The change in name was found advisable in view of the recent purchase of the Borromite Co. of America that manufactured Borromite water softening systems. These will be marketed hereafter under the name Wayne water softening systems.

BELKNAP Hardware & Mfg. Co. of Louisville, Ky., has recently contracted for the construction of a new power plant building on a new site at the northeast corner of Snead and Washington Streets which will occupy a space 84 by 95 ft. The new plant will have 1200 hp. boiler capacity and the total rating of the turbo generators will be 800 kw., with railroad connections and automatic coal and ash handling machinery.

THE FIRST LARGE FREIGHTER to be loaded entirely with Celite products recently left Port San Luis, California, bound for Atlantic ports by way of the Panama Canal. A second freighter is now receiving its cargo, and this will be followed by still another boat also devoted exclusively to their materials. Although the Celite Products Co. has made water shipments quite frequently in the past to the Atlantic coast, this is the first time that three entire vessels have been used to the exclusion of other cargoes.

THE UNITED MACHINE & MFG. CO., of Canton, Ohio, has purchased complete interest in the Harrington stoker from the James A. Brady Foundry Co., Chicago, Ill. The plant facilities, organization and engineering personnel of the United Machine & Mfg. Co. assure the continuance of the rapid commercial development of the Harrington stoker, which has been taken over in such manner as will involve no interruption of production or delay in service to present users of the Harrington stoker.

Book Reviews

PRINCIPLES OF MECHANICAL REFRIGERATION by H. J. Macintire; size 5½ by 8 in., 252 pages, cloth; New York, 1922.

Mechanical refrigeration is not a detached self-sufficient science in itself and should not be considered as such. It is simply an application of the general science of heat engineering which makes use of the same laws that apply to steam engineering, heating and ventilation, air compression and other similar branches of mechanical engineering. In making a study of this subject then, it is desirable to connect it as far as practical with these other branches in order to be able to understand the underlying fundamentals. The subject has been treated here from that point of view, taking up first the fundamental concepts of heat engineering.

Other subjects taken up in order are the compressor, condensers, ammonia piping and accessories, other refrigerating systems, erection and operation, refrigerants, heat transfer, piping and piping calculations, ice making, and other applications of refrigeration.

The book is in reality a compilation of a series of separate and complete articles which were written in original form as study course covering the entire field of refrigeration in an elementary manner. The amount of mathematics used has been reduced to a minimum and the process has been made clear by frequent analogies to steam engineering principles.

HENDEY 1870-1920, is the title of a book citing the origin and achievements of the Hendey Machine Co., of Torrington, Conn., during the 50 yr. of its existence. The book is dedicated "To the men who build our machines and in the building strive for perfection; to the friends who use our machines and in the using realize our aims." The reading of this book will prove an inspiration to any workman who has an original idea which must be worked out and developed into mechanical form before it can be of tangible value to the inventor or the people who could use the device. The early struggles of Henry J. and Arthur Hendey, founders of the company, are told briefly, the author evidently keeping in mind the characteristics of the men which were predominant in making the business the success that it has been. The story of the progress made by the company throughout the half century of its existence covers the growth of the factory, improvements in products, patents and their outgrowth, standardizing of parts, export activities and war work. Beautifully and profusely illustrated, the book tells in pictures as well as words the history of an American industry which is the outgrowth of an idea surrounded by ideals.

PRACTICAL ELECTRICAL ENGINEERING, by Harry G. Cisin; size, 5½ by 8; cloth, 324 pages, 68 illustrations; New York, N. Y.; 1922.

The keynote of this book is simplicity. The only requisite for a full comprehension of the text is a knowledge of simple arithmetic, for mathematical derivations and proof are dispensed with.

The book is intended for use in industrial and evening schools as well as a home-study text, and takes up only the study of direct current electrical engineering. It is laid out according to a specific and logical plan which carries the student from fundamental units and laws of electrical engineering through to the study of dynamos and motors.

There are a number of men engaged in the electrical industry who have had neither the time nor opportunity to obtain even a general knowledge of electrical science. Such men will find in this book the facts they have been looking for presented in a simplified but not childish form.

MECHANICAL WORLD, Electrical Pocket Book, 1922 edition, 4 by 6¼; cloth, 394 pages, 108 illustrations; Manchester, England.

The present issue of this popular little reference book has been enlarged somewhat and its scope extended to a section on Power Station Construction and Operation. The section on switchgear and switchboards has been rewritten and extended so as to cover the latest developments in this important branch of the subject. Another new section dealing with electric hoists contains much practical information and many useful hints on the construction and installation of such equipment.

Catalog Notes

THE LATEST circular on O-B radiator valves has been received from The Ohio Brass Co., Mansfield, O.

MULTI-STAGE automatically balanced centrifugal pumps are the subject of the latest bulletin from Dayton-Dowd Co., Quincy, Ill.

A CONDENSED BULLETIN covering Hardinge conical ball and pebble mills, has just been issued by Hardinge Co., Inc., 120 Broadway, New York.

FORTY YEARS OF PROGRESS is the title of a recently published pamphlet announcing the change in name from the Heine Safety Boiler Co. to the Heine Boiler Co. and several new developments in boiler design.

HILLS-MCCANNA CO.'S new general catalog comprises description, illustrations and new price lists of the company's improved force feed lubricators, hand oil pumps, fusible plugs, boiler test pumps, high pressure gage cocks, and other devices.

BULLETIN 10,004 just issued by Ingersoll-Rand Co., describes Price Type "PO" horizontal, single cylinder, single acting, direct-injection oil engine. Probably the most outstanding feature of the design of these engines is the shape of the combustion chamber and the arrangement and construction of the spray nozzles used for direct-injection of fuel.

ATLAS VALVE CO. has just issued a handbook on reducing valves in which the whole matter of reducing valve economics is fully covered. The handbook goes into careful and complete detail on all points that are closely connected with and vital to reducing valves. The flow of steam through pipes is handled in a decidedly simple and understandable manner. Handy tables make it possible for the user to determine at a glance just what a given pipe size will do. Or, the tables will enable the user to select the proper size of pipe needed for a given weight of steam per minute. Reducing valve sizes are completely covered. Other important features are superheated steam, extra heavy pipe, pipe fittings, leaders to heating systems, pipe friction allowances, steam velocities, etc.